Postpartum pelvic floor symptoms and early physical therapy intervention

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Thesis for the degree of Philosophiae Doctor

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Grindarbotnseinkenni eftir fæðingu og snemmíhlutun með sjúkraþjálfun

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Ritgerð til doktorsgráðu

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To my mother, the midwife

“It is not enough, however, merely to keep a woman alive; it is important, to preserve for her the function of her reproductive system and to prevent injury so far as possible, in order that the involved organs may again approximate a normal state.” (Arnold H. Kegel 1948)

Ágrip

Markmið: Meginmarkmið þessa doktorsverkefnis var að kanna tíðni grindarbotnseinkenna og vanlíðunar sem þau valda frumbyrjum á fyrstu mánuðum eftir fæðingu, ásamt því að rannsaka hvort tengsl findust milli grindarbotnseinkennanna og fæðingartengdra þátta. Annað meginmarkmið var að kanna áhrif snemmbærrar grindarbotnsþjálfunar, sem stýrt var af sjúkraþjálfara, í hópi frumbyrja með einkenni frá grindarbotni. Þriðja markmið var að kanna áhrif íþróttaiðkunar fyrir fæðingu hjá afreksíþróttakonum á fæðingarútkomu fyrstu fæðingar. Þrjár vísindagreinar sem byggðar voru á þremur rannsóknum eru hluti af þessari ritgerð. Sértæk markmið voru:

Rannsókn I: Að kanna tíðni grindarbotnseinkenna og vanlíðunar sem tengdist einkennunum hjá norður-evrópskum frumbyrjum 6-10 vikum eftir fæðingu og bera saman fæðingu um fæðingarveg og með keisaraskurði.

Rannsókn II: Að kanna áhrif einstaklingsmiðaðrar grindarbotnsþjálfunar, sem sjúkraþjálfari leiðir á fyrstu mánuðum eftir fæðingu, á þvag- og endaþarmsleka og þá vanlíðan sem slík einkenni valda hjá frumbyrjum. Áhrif slíkrar þjálfunar á styrk og vöðvaúthald í grindarbotni var einnig metin.

Rannsókn III: Að kanna fæðingarútkomu, þar á meðal tíðni bráðakeisaraskurða, lengdar fyrsta og annars stigs fæðingar og alvarlegra spangarrifa hjá frumbyrjum sem voru annaðhvort afreksíþróttakonur eða konur sem ekki æfðu íþróttir.

Aðferðir: *Rannsókn I* var þversniðsrannsókn með 721 manns úrtaki frumbyrja sem fæddu einbura á höfuðborgarsvæðinu Reykjavík. Frá apríl 2015 til mars 2017 svöruðu þátttakendur rafrænum spurningalista heima 6-10 vikum eftir fæðingu. Upplýsingum um þvag- og endaþarmsleka, sig grindarholslíffæra og vandkvæðum tengd kynlífi ásamt tengdri vanlíðan var safnað og borið saman við gögn frá íslensku fæðingarskráningunni. Meginútkomubreytur voru framangreind grindarbotnseinkenni eftir fæðingu og tengd vanlíðan. *Rannsókn II* var slembi-samanburðarrannsókn til að kanna áhrif grindarbotnsþjálfunar, sem leidd var af sjúkraþjálfara, á tíðni þvag- og endaþarmsleka (aðal-útkomubreytur). Mæliaðilinn var blindaður á rannsóknahópana. Vanlíðan tengd raunverulegum einkennum, ásamt mati á styrk og úthaldi vöðva í grindarbotni voru flokkaðar sem aðrar útkomubreytur. Frá árinu 2016 til 2017 voru svör kvenna sem tóku þátt í *Rannsókn I* athuguð til að finna konur sem uppfylltu skilyrði til þátttöku. Þetta var gert um leið og

konur skiluðu svörunum 6-10 vikum eftir fyrstu fæðingu. Níutíu og fimm konum sem töldust vera með þvagleka samkvæmt svörun spurningalistans var boðið að taka þátt. Af þeim þáðu 84 boðið. Samtals var 41 konu slembiraðað í íhlutunarhóp og 43 í samanburðarhóp. Þrjár og ein kona hættu þátttöku úr þessum tveim hópum. Íhlutunin, sem hófst um 9 vikum eftir fæðingu, samanstóð af 12 vikulegum tímum með sjúkraþjálfara. Eftir það voru útkomubreytur metnar (~ 6 mánuðum eftir fæðingu). Viðbótar-eftirfylgni var framkvæmd um 12 mánuðum eftir fæðingu. Samanburðarhópurinn fékk engar sértækar leiðbeiningar eftir upphaflegu skoðunina. *Rannsókn III* var afturskyggn tilfella-viðmiðuð rannsókn þar sem fæðingarútkoma fyrstu fæðingar afreksíþróttakvenna var borin saman við útkomu kvenna sem ekki æfðu íþróttir. Íþróttakonurnar voru flokkaðar samkvæmt há-þungaberandi og lág-þungaberandi íþróttagreinum. Íþróttakonurnar höfði fyrir fyrstu fæðingu keppt með landsliðum eða tekið þátt í keppnum á alþjóðlegum vettvangi eða verið í sambærilegri stöðu í sinni íþróttagrein. Samtals tóku 248 konur þátt, 89 voru í há-þungaberandi og 41 í lág-þungaberandi íþróttum og 118 konur í samanburðahópi. Einennum kvenna sem skiptu máli fyrir rannsóknina ásamt svörum um tíðni íþróttaiðkunar í að minnsta kosti þrjú ár fyrir fyrstu meðgöngu og upplýsingum um almenna hreyfingu þeirra var safnað með spurningalista sem sendur var með tölvupósti. Upplýsingar fengust frá íslensku fæðingarskráningunni um tiltekin atriði varðandi fyrstu fæðingu allra þeirra kvenna sem tóku þátt í rannsóknunum.

Niðurstöður: Í *Rannsókn I* var tíðni þvagleka 48% og tíðni endaþarmsleka 60%, auk þess sem 27% og 56% þátttakenda þjáðust af vanlíðan sökum þessa í viðkomandi hópum. Sigeinkenni grindarholslíffæra fundust hjá 29% kvenna og af öllum þátttakendum sögðust 13% glíma við vanlíðan vegna þess. Fimmtíu og fimm prósent kvennanna sögðust vera kynferðislega virkar, af þeim greindu 66% frá sársauka við samfarir. Af öllum þátttakendum sögðust 48% upplifa vanlíðan vegna kynlífstengdra atriða. Þvagleki með undirflokkum og sig á líffærum grindarhols var algengari hjá konum sem fæddu um fæðingarveg borið saman við keisaraskurð, en ekki fannst marktækur munur þegar um endaþarmsleka og sársauka við samfarir var að ræða. Að vera í offituflokki, borið saman við eðlilega þyngd (LÞS<25kg/m^2)[1] var tengt aukinni hættu á þvagleka hjá konum sem fæddu um fæðingarveg (LH[2] 1.94; 95% ÖB[3] 1.20-3.14). Fyrir konur sem fæddu um fæðingarveg var

[1] Líkamsþyngdarstuðull
[2] Líkindahlutfall
[3] Öryggisbil

fæðingarþyngd yfir 50. hlutfallsmarki einnig áhættuþáttur fyrir bráðaþvagleka (LH 1.53; 95% ÖB; 1.05-2.21). Auk þess var spangarskurður tengdur auknum líkum á endaþarmsleka fyrir sama hóp kvenna (LH 2.19; 95% ÖB; 1.30-3.67). Engin tengsl fundust milli einkenna móður eða einstakra fæðingarbreyta við grindarbotnseinkenni hjá konum sem fæddu með keisaraskurði. Í *Rannsókn II* var þvagleki marktækt minni í lok meðferðar hjá íhlutunarhóp, með 21 konu (57%) enn með einkenni borið saman við 31 (82%) í samanburðarhópi (p=0,33). Einnig var þvagleka-tengd vanlíðan minni í íhlutunarhópnum, með 10 konur (27%) sem enn fundu fyrir slíku borið saman við 23 (60%) í samanburðarhópnum (p=0,005). Endaþarmsleki minnkaði ekki við grindarbotnsþjálfunina og var ekki marktækur munur á hópunum við lok meðferðar (p=0,33). Ekki fannst heldur munur á vanlíðan sem tengdist endaþarmsleka við lok meðferðar (p=0,82). Meðaltalsmunur hópanna á styrkbreytingum grindarbotnsvöðva var 5 hPa[4] (95% ÖB 2-8; p=0,003), og varðandi úthaldsbreytingar var munurinn 50 hPa/sek (95% ÖB 23-77; p=0,001), hvort tveggja íhlutunarhópnum í vil. Meðaltalsmunur hópanna á styrkbreytingum hringvöðva endaþarms var 10 hPa (95% ÖB 2-18; p=0,01). Úthaldsbreytingin var 95 hPa/sek (95% ÖB 16-173; p=0,02), hvor tveggja íhlutunarhópnum í vil. Við eftirfylgni 12 mánuðum eftir fæðingu var ekki munur milli hópa á tíðni þvag- eða endaþarmsleka né tengdri vanlíðan. Styrk- og úthaldsmunur bæði grindarbotnsvöðva og hringvöðva endaþarms íhlutunarhópnum í vil, var enn til staðar. Í *Rannsókn III* fannst enginn munur milli hópa á tíðni bráðakeisaraskurðar né lengdar á fyrsta og öðru stigi fæðingar. Tíðni þriðju og fjórðu gráðu spangarrifa var marktækt hærri (23,7%) hjá konum sem æfðu lág-þungaberandi íþróttir borið saman við há-þungaberandi (5,1%, p=0,01). Enginn munur fannst þegar hvor íþróttahópurinn um sig var borinn saman við samanburðarhóp (12%, p=0,09 fyrir lág-þungaberandi og p=0,12 fyrir há-þungaberandi íþróttahópinn). Tíðni íþóttaiðkunar fyrir- og á meðgöngu, aldur móður eða LÞS fyrir fæðingu hafði ekki áhrif á útkomu og gang fæðingar.

Ályktanir: Einkenni frá grindarbotni og vanlíðan sem tengdist þeim var algeng hjá frumbyrjum á fyrstu vikum eftir fæðingu. Ekki ætti að líta fram hjá þessu né þeim áhrifum sem grindarbotnsveikleiki hefur á konur. Hjá hópi kvenna með einkenni frá grindarbotni dró grindarbotnsþjálfun úr þvagleka og tengdri vanlíðan 6 mánuðum eftir fæðingu auk þess að bæta styrk og úthaldsgetu vöðva í grindarbotni. Endaþarmsleki minnkaði hins vegar ekki við íhlutunina. Þegar skoðaður var hópur kvenna með tilliti til líkamsþjálfunar fyrir

[4] hectoPascals

fyrstu fæðingu, fannst ekkert samband mikillar íþróttaiðkunar á afreksstigi og verri útkomu fæðingar þegar metin var lengd fyrsta og annars stigs fæðingar, tíðni bráðakeisaraskurða og alvarlegar spangarrifur. Margar konur glíma við tiltölulega mild einkenni frá grindarbotni eftir fæðingu, einkenni sem eru líkleg til að minnka á fyrsta árinu eftir barnsburð. Bera þarf kennsl á þann hóp kvenna sem á við alvarleg grindarbotnseinkenni og vanlíðan að stríða þar sem þær eru líklegar til að hafa gagn af sérmiðaðri sjúkraþjálfun.

Lykilorð: Afreksíþróttakonur, eftir fæðingu, fæðing, grindarbotnseinkenni, grindarbotnsþjálfun..

Abstract

Aims: The overall objective of this doctoral project was to study the prevalence of pelvic floor dysfunction and bother (discomfort, worry or something annoying) related to this, and to investigate associations with delivery factors, in first-time mothers during the first months after childbirth. Another main objective was to study the influences of early physical therapy intervention on pelvic floor symptoms in a subgroup of symptomatic women. A third goal was to study the influence of pre-delivery physical stress on childbirth outcomes among athletes. Three articles are included in this thesis, based on three separate studies. The specific aims of these studies were:

Study I: To study the prevalence of pelvic floor dysfunction and related bother in Caucasian primiparous women 6-10 weeks postpartum and compare vaginal delivery and cesarean section in this respect.

Study II: To study the effects of individual one-on-one physical therapist-guided pelvic floor muscle training in the early postpartum period on urinary and anal incontinence and related bother, as well as pelvic floor muscle strength and endurance.

Study III: To study delivery outcomes, including emergency cesarean section rates, the length of the first and second stages of labor and the risk for severe perineal tears, in first-time pregnant elite athletes compared to non-athletes.

Methods: *Study I* was a cross-sectional study with a sample of 721 first-time mothers with singleton births set in the greater capital area of Reykjavik, Iceland. From April 2015 to March 2017 participants answered an electronic questionnaire at home 6-10 weeks after birth. Reports on urinary- and anal incontinence, pelvic organ prolapse, sexual dysfunction and related bother, along with delivery information, were collected and analyzed. The main outcome measures were prevalence of postpartum pelvic floor dysfunction and related bother. *Study II* was an assessor-blinded parallel randomized controlled trial evaluating effects of pelvic floor muscle training lead by a physical therapist on the rate of urinary and/or anal leakage (primary outcomes). Bother related to the primary outcomes, muscle strength and endurance in the pelvic floor and were secondary outcomes. Between 2016-2017 women participating in Study I were screened for eligibilty 6-10 weeks

after childbirth. Of those identified as urinary incontinent 95 were invited to participate of whom 84 agreed. Forty-one and 43 women were randomized to respctively the intervention and control groups. Three and one participants withdrew from each respective group. The intervention, starting at ~9 weeks postpartum consisted of 12 weekly sessions with a physical therapist after which the main outcomes were assessed (endpoint, ~6 months postpartum). Additional follow-up was conducted at ~12 months postpartum. The control group received no instructions after the initial assessment. *Study III* was a retrospective case-control study comparing birth outcomes of primiparous female elite athletes engaging in high- and low-impact sports, compared to non-athletic controls. The athletes had prior to birth competed at national team level or equivalent. There were 248 participants; 89 high- and 41 low-impact elite athletes, and 118 controls. Participant characteristics and frequency of training for at least three years before a first pregnancy were collected via a self-administered questionnaire. In all studies relevant information of delivery outcomes was retrieved from the Icelandic Medical Birth Register.

Results: In *Study I* the prevalence of any urinary and anal incontinence was 48% and 60%, respectively, with 27% and 56% of the total sample experiencing such symptoms as bothersome. Pelvic organ prolapse symptoms were experienced by 29%, with 13% of all the women finding it bothersome. Fifty-five percent of the women reported to be sexually active, of them, 66% reported pain during intercourse. Among all participants, 48% found sexual issues to be bothersome. Urinary incontinence along with subtypes and pelvic organ prolapse symptoms were more prevalent in women who delivered vaginally compared to by cesarean section. No differences in prevelance were observed for anal incontinence and pain during intercourse between the groups. Compared to women of normal weight (BMI<25kg/m^2)[5] being obese was a significant predictor for urinary incontinence among women delivering vaginally (OR[6] 1.94; 95% CI[7] 1.20-3.14). For vaginal birth, birthweight above the 50th percentile was also predictor for urgency urinary incontinence (OR 1.53; 95% CI; 1.05-2.21). Use of episiotomy was a significant predictor of anal incontinence (OR 2.19; 95% CI; 1.30-3.67). No associations between maternal and delivery characteristics were associated with pelvic floor dysfunction among women undergoing

[5] Body mass index

[6] Odds ratio

[7] Confidence interval

cesarean section. In *Study II*, when measured at endpoint, urinary incontinence was less frequent in the intervention group with 21 (57%) still symptomatic compared to 31 (82%) of the controls (p=0.03), as was bladder-related bother with 10 (27%) in the intervention vs. 23 (60%) in the control group, p=0.005. Anal incontinence was not influenced by pelvic floor muscle training (p=0.33), nor was bowel-related bother (p=0.82). The mean differences between groups in terms of measured pelvic floor muscle strength changes at endpoint was 5 hPa (95% CI 2-8; p=0.003), and for pelvic floor muscle endurance changes, 50 hPa/sec (95% CI 23-77; p=0.001), both in favor of the intervention group. The mean between-group difference for anal sphincter strength changes was 10 hPa (95% CI 2-18; p=0.01), and for anal sphincter endurance changes 95 hPa/sec (95% CI 16-173; p=0.02), both in favor of the intervention. At the follow-up visit 12 months postpartum, no differences were observed between the groups regarding rates of urinary and anal incontinence, or related bother. Pelvic floor- and anal muscle strength and endurance favoring the intervention group were maintained. In *Study III* no significant differences were found between the groups regarding incidence of emergency cesarean section or the length of the first and second stages of labor. The incidence of 3^{rd}- 4^{th} degree perineal tears was significantly higher (23.7%) among low- impact athletes than in the high-impact group (5.1%, p=0.01), but no significant differences were seen when the athletes were compared to controls (12%, p=0.09 for low-impact and p=0.12 for high-impact athletes). The frequency of exercise before and during pregnancy, maternal age and BMI had no significant association with any delivery outcome.

Conclusions: Bothersome pelvic floor dysfunction was prevalent among first-time mothers in the immediate postpartum period. This reflected on actual symptoms and on bother at this point in time after childbirth. This should be considered of clinical value and not ignored. In a subgroup of symptomatic women, postpartum pelvic floor mucle training had decreased the rate of urinary incontinence and related bother 6 months postpartum and it also increased muscle strength and endurance. Anal incontinence was, however, not influenced by the intervention. When analyzing another subgroup of women in relation to physical activity before the first childbirth, no association was found between participating in competitive sports at elite level and adverse delivery outcomes, including length of labor, the need for cesarean section during delivery or severe perineal tears. After childbirth women often show symptoms of relatively mild pelvic floor dysfunction which for most of them is likely to improve in the first year after childbirth. The

subgroup with more bother and worse symptoms should be identified as they are likely to gain from targeted physiotherapy.

Keywords: Childbirth, elite athletes, pelvic floor dysfunction, pelvic floor muscle training, postpartum.

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I would like to express my deepest gratitude to everyone involved with this project and who helped me along the way. Without this invaluable assistance, understanding, guidance and motivation it would have been difficult to accomplish this task.

The work that this thesis is based on was carried out at the Faculty of Medicine in the University of Iceland, at the Department of Obstetrics and Gynecology, Women´s Clinic (Kvennadeild) at Landspitali University Hospital and at Táp Physical Therapy Clinic. I would like to thank these institutions and their staff for their help. I wish to express my deepest appreciation to my advisors and supervisors, mentors and partners, Kari Bø, Þóra Steingrímsdóttir and Reynir Tómas Geirsson for their expertise, passion and knowledge which they have shared with me through these times. My gratitude goes to the other members of my doctoral committee: Hildur Harðardóttir for good advice and to Þórhallur Ingi Halldórsson for providing statstical advice and quick responses when needed. I would like to thank all of them for their contribution to planning and executing the work described in this thesis. Special thanks go to statistican Thor Aspelund, for his advice on the statistical analysis of the data. My deepest gratitude extends also to my dear colleagues and coworkers, Guðrún Magnúsdóttir and Fanney Magnúsdóttir, physical therapists, for supervising the intervention sessions for the participants in Study II. Warm thanks go to Hulda Magnúsdóttir, former secretery at Táp, for supervision of the randomization process and booking of the women participating in Study II. Lastly special thanks go to all the women who participated in the studies, - without their participation this work would not have been possible.

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Contents

List of abbreviations

AI	anal incontinence
BMI	body mass index
CI	confidence interval
CS	cesarean section
EAS	external anal sphincter
EMG	electromyographic
IAP	intra-abdominal pressure
IAS	internal anal sphincter
ICS	International Continence Society
IUGA	International Urogynecological Association
LH	levator hiatus
OR	odds ratio
PFD	pelvic floor dysfunction
PFM	pelvic floor muscles
PFMT	pelvic floor muscle training
POP	pelvic organ prolapse
RCT	randomized controlled trial
SD	standard deviation
SUI	stress urinary incontinence
UI	urinary incontinence
UUI	urgency urinary incontinence
VD	vaginal delivery

List of figures

Figure 1 is reproduced with kind permission from dr. Joe Musculino (**www.learnmuscles.com**). Figures 2 and 3 are reproduced with kind permission from Elsevier.

List of tables

List of original papers

This thesis is based on the following original publications, which are referred to in the text by their Roman numerals (I-III):

I. Sigurdardottir T, Bø K, Steingrimsdottir T, Halldorsson TI, Aspelund T, Geirsson RT. **Pelvic floor dysfunction and pelvic outlet bother in primiparous women 6-10 weeks postpartum – a comparison between vaginal and cesarean delivery.** Manuscript is under review at the International Urogynecology Journal.

II. Sigurdardottir T, Steingrimsdottir T, Geirsson RT, Halldorsson TI, Aspelund T, Bø K. **Can postpartum pelvic floor muscle training reduce urinary and anal incontinence? An assessor-blinded randomized controlled trial.** *Am J Obstet Gynecol.* 2020 Mar;222:247.e1-8. doi: 10.1016/j.ajog.2019.09.011. Epub 2019 Sept 14.*

III. Sigurdardottir T, Steingrimsdottir T, Geirsson RT, Halldorsson TI, Aspelund T, Bø K. **Do female elite athletes experience more cimplicated childbirth than non-athletes? A case-control study.** *Br J Sports Med.* 2019 Mar;53(6):354-358. doi: 10.1136/bjsports-2018-099447. Epub 2018 Sep 18.**

In addition, some unpublished data is presented:

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Additional scientific articles published prior to the PhD period but related to the subject are:

Ludviksdottir I, Hardardottir H, Sigurdardottir T, & Ulfarsson GF. **Samanburður á styrk grindarbotnsvöðva hjá keppnisíþróttakonum og**

óþjálfuðum [Comparison of pelvic floor muscle strength in competition-level athletes and untrained women]. *Laeknabladid [Icelandic Medical Journal].* 2018, Mar;104(3):133–138. doi:10.17992/lbl.2018.03.177

Sigurdardottir T, Steingrimsdottir T, Arnason A, & Bø K. **Pelvic floor muscle function before and after first childbirth**. *Int Urogynecol J*, 2011, Dec;*22*(12):1497–1503. doi:10.1007/s00192-011-1518-9. Epub 2011 Jul 26.

Sigurdardottir T, Steingrimsdottir T, Arnason, A, & Bø K. (2009). **Test-retest intra-rater reliability of vaginal measurement of pelvic floor muscle strength using Myomed 932.** *Acta Obstetricia et Gynecologica Scandinavica.* 2009;88(8):939-43. doi:10.1080/00016340903093567

Declaration of contribution

I designed the research questions described in this thesis, together with professors Kari Bø, Reynir Tómas Geirsson and Þóra Steingrímsdóttir. I took part in all phases of planning and performance of the studies in this thesis. This included the preparation of reserach protocols, applications for necessary permissions and funding, preparation of the questionnaires used, enrollment of participants and data collection. I supervised recruitment of women who contributed to data in Articles I, II and III and educated and prepared co-workers, both among the midwifery staff in the Women´s Clinic, Landspitali, and the physical therapists in Táp outpatient Physical Therapy Clinic who carried out the intervention decribed in Study II. I conducted measurements in Study II. I collected the data and performed the statistical analyses described in all the articles along with professors Þórhallur I. Halldórsson and Thor Aspelund. I participated in drawing conclusions and formulating how they were set forth, wrote the various drafts of Articles I, II and III, participated in all subsequent revisions and prepared the final manuscripts for submission.

1 Introduction

The American gynecologist, Arnold Kegel, was the first to demonstrate in his studies published in the late 1940ies the value of pelvic floor muscle training (PFMT) as a treatment for weak or weakened pelvic floor muscles (PFM) and symptoms of urinary incontinence (UI) that could affect women adversely. Kegel stated that it was not enough that a woman survived childbirth, but that she should come through this having preserved the function of her reproductive system, having escaped serious injury and consecutively be in an approximately normal state or as she would have been before the pregnancy (Kegel, 1948).

An increasing number of women do no longer accept a life with bother (defined as discomfort, trouble, nuisance, worry or something annoying ("Cambridge Dictionary," n.d.)) and suffering from pelvic floor dysfunction (PFD) without seeking help and advice. Modern life provides opportunities for enjoying life to an extent which makes PFD and it´s symptoms not tolerable in the way which previous generations may have put up with. PFD can decrease quality of life and lead to a more sedentary lifestyle which in turn and in the long run escalates also the risk of lifestyle diseases, such as obesity and its associated health problems (Bo, 2004b). Nevertheless, at the same time there are still some women who do not complain and accept their fate (Hägglund & Wadensten, 2007; Howard & Steggall, 2010; Tinetti et al., 2018).

Today, most women live a long life after giving birth to their children. Therefore, it is important to observe and categorize the weakness and symptoms that women possibly endure from pregnancy and childbirth, as well as to consider therapeutic and behavioral options to optimize quality of life after childbirth. General recreational physical activity and participation in exercise and even competitive sports has in the last decades grown substantially and such activities are now considerably more common among women compared to when Kegel published his studies. Pelvic floor symptoms and weaknesses are, however, known to influence physical activity and sporting performance in women as well as to reveal deficiencies and problems sustained after childbirth (Bo, 2004b; Casey & Temme, 2017). Such drawbacks are likely to seriously affect quality of life in a broad sense. While this applies to women in general and at any age, those women who actively pursue and try to excel in competitive sports might be more prone to

experiencing adverse effects of a weakened pelvic floor. Therefore, they merit specific attention, not least within the fields of physical therapy, urogynecology and sports medicine.

Elite female athletes, especially endurance athletes, are often at their peak in sporting life and performance ability at the same time as their fertility is at its best. Possible influences of pregnancy and delivery on athletic performance can have a particular impact when female athletes commence their reproductive life and become pregnant. The provision of supportive and remedial therapy for both “ordinary” and elite sportswomen as well as women in general, rests in modern society largely with physical therapists who often have a central position in women´s health care for giving the expert prolonged care that will help women to cope with PFD and symptoms that arise anew after childbirth and in a changed life situation. In this context research and increased knowledge assumes a central value in order to conserve and promote women´s health and wellbeing.

The idea for this doctoral study was to gain a new perspective and knowledge in a healthy female population into the symptoms which women experience from their pelvic floor after a first childbirth and explore whether early physical therapy interventions could influence and improve those symptoms. I was also interested to study a subgroup of elite athletes to understand and assess if these very fit women would experience more complicated deliveries than other women. Would women with a supposedly stronger pelvic floor be more liable to birth injury? This has been claimed (Kruger, Dietz, & Murphy, 2007), but also and conversely it has been found that for them birth could also be easier (Du, Xu, Ding, Wang, & Wang, 2015). Added knowledge in this field might help to clarify what can change and what is preserved in relation to pelvic function after a first childbirth.

Each little milestone towards better women´s health matters.

1.1 The female pelvic floor

1.1.1 Anatomy of the pelvic floor

The structures of a healthy female pelvic floor are complex and there is not complete agreement on their configuration and layers. Their function is to maintain support for the pelvic organs during rest and activity. During rise in intra-abdominal pressure (IAP) together with muscular contraction, the PFM are central to the closure mechanism around the female pelvic openings. Through relaxation of the PFM, they facilitate the release of urine and feces

in our daily life. At the birth of a child they are stretched and tested in a critical way (Ashton-Miller & Delancey, 2007). This layer of muscles, ligaments and fascias extends from the sides of the pelvic bones in an apron-like fashion and connect in the midline to form the hollow floor of the pelvis sloping obliquely downwards and forwards. From the pubic bones anteriorly to the perineal body and sacrum and coccyx posteriorly, bound by muscles and fascias laterally, lies the urogenital triangle or hiatus where the urethra and the vagina pass through the pelvic floor. Posterior to the perineal body lies the rectal hiatus with the passage on the anal canal (Gray & Standring, 2005). The whole area is called the levator hiatus (LH) (Figure 1).

The deep layer of the PFM and fascias, often referred to as the pelvic diaphragm, consists mainly of the levator ani muscles which make up most of the muscular mass of the pelvic floor. It is divided into three parts, the pubococcygeus, iliococcygeus and ischiococcygeus muscles on each side. The ischiococcygeus, often referred to as the coccygeus muscle, is the most posterior and superior muscle, attaching to the coccyx and the ischial spines. Another and separate muscle forming the postero-lateral wall of the pelvis is the piriformis muscle. The obturator internus covers the antero-lateral wall of the pelvis where its fascia connects to the levator ani muscle. The pubococcygeus muscles are often divided into parts according to the pelvic viscera to which they connect; in the female it is the puborectalis and pubovaginalis muscle parts, with the latter surrounding the vagina and urethra (Figure 1). Muscle fibers from the PFM are often connected into adjoining muscles and fascias, such as fibers from the puborectalis blending with fibers from the external anal sphincter (EAS) and fibers from the pubovaginalis joining the urethral sphincter complex, which consists of the intrinsic striated and smooth muscles of the urethra. The pubovaginalis forms a sling around the posterior wall of the vagina and blends into the perineal body, but also attaches to the anorectal junction (Gray & Standring, 2005).

The endopelvic fascia, which covers the upper surface of the levator ani muscle and mixes with the visceral pelvic fascia, is considered to be of definite clinical importance. It merges as well with the fascias of piriformis and obturator internus muscles. These structures contribute to the tendinous arch of the levator ani and below it, in the endopelvic fascia, is the tendinous arch of the pelvic fascia, which lies from the lower part of the symphysis pubis to the lower margin of the ischial spine (Gray & Standring, 2005). These fascias together with the levator ani muscles, have key roles in urethral and vaginal support (DeLancey, 1994) (Figure 1). The tendinous arch of the pelvic fascia is also the origin of the lateral ligament of the urinary bladder. In front the

same fascia forms the paired pubourethral ligaments. It has been stated that the most important support of the urethra and its sphincters comes from the connective tissue support in the ventral wall of the vagina (Fritsch et al., 2006).

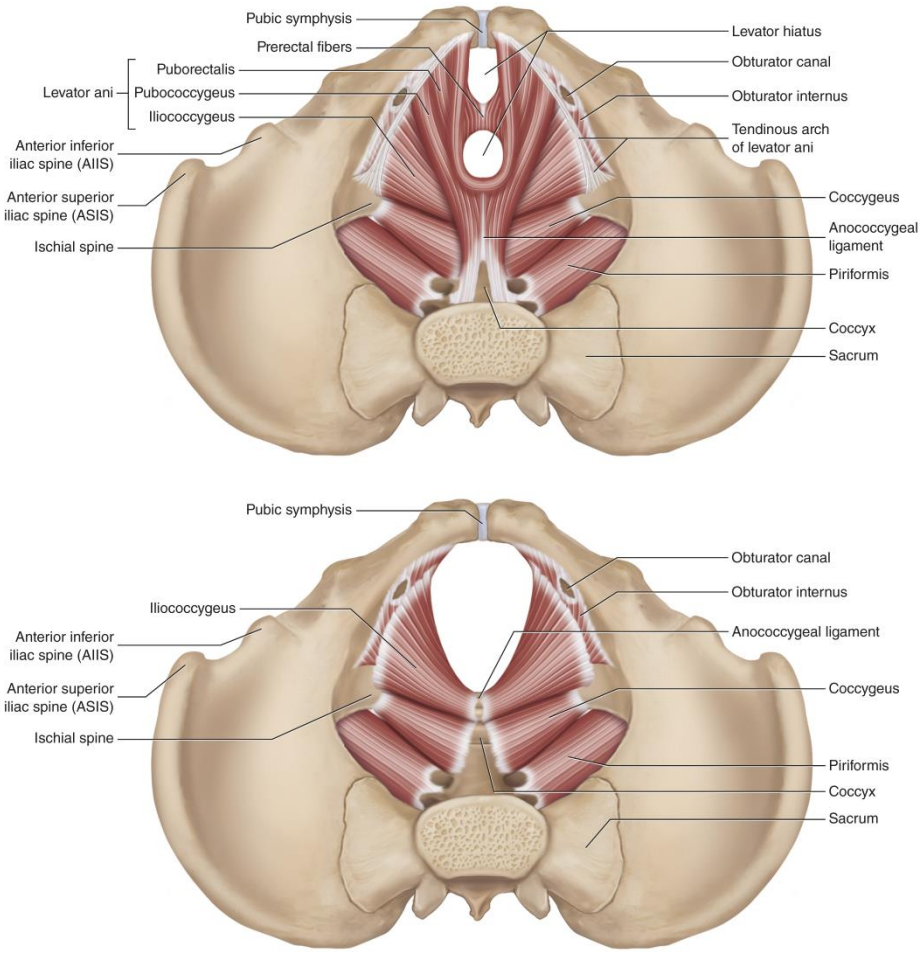

Figure 1. The pelvic floor muscles. Reproduced with permission from dr. Joe Muscolino (www.learnmuscles.com).

The superficial layer of the pelvic floor consists of fascias such as the perineal membrane inferiorly, the ischiocavernosus, bulbospongiosus and transversus perinei superficialis- and profundus muscles, together known as the perineal muscles, and the sphincter mechanisms, i.e. the EAS, sphincter urethrae, urethrovaginal sphincter and compressor urethrae muscles. The perineal body is the tendinous central area between the anus and the vagina in the midline and connects structures from both sides in the midline. It is in origin fibromuscular and is continuous with the perineal membrane. Many

structures connect into the perineal body, fibers from the EAS, pubococcygeus (pubovaginal and puborectal parts), transversus perinei profundus and superficialis, bulbospongiosus muscles and fascias in the area (Gray & Standring, 2005).

The anal sphincter complex consists of the internal anal sphincter (IAS), the EAS which covers the former and extends more caudally, and the puborectalis muscle which merges with the EAS. The puborectalis muscle with its sling around the anorectal junction forms the anorectal angle which is important in maintaining anal continence (Erden, 2018). The urogenital hiatus is often referred to as the urogenital hiatus of the levator ani (Ashton-Miller & Delancey, 2007).

Somatic and autonomic innervation of the pelvic floor is from the spinal segments S2-5, both from direct branches and from the pudendal nerve or perineal branches of the pudendal nerve (Gray & Standring, 2005; Vodušek, 2015)

1.1.2 Function of the pelvic floor

1.1.2.1 Muscle fiber types

The distribution and proportion of different striated muscle fiber types in individual muscles in the human body is mostly determined by genetics (Simoneau & Bouchard, 1995). Hypertrophy is possible in both type I (slow twitch) and II (fast twitch) muscle fibers, although this is more prominent in type II fibers (Green, Goreham, Ouyang, Ball-Burnett, & Ranney, 1999).

The external urethral sphincter is made up of type I fibers without muscle spindles, suggesting that its function is to maintain activity over a longer time and thus add to urethral closure (Gosling, Dixon, Critchley, & Thompson, 1981). The levator ani muscle has both type I and type II muscle fibers, with muscle spindles indicating that its function can also be active support in urethral closure during an increase in IAP (Gosling et al., 1981). Both the levator ani and fascias in the pelvic floor have some smooth muscle cells embedded which could add to tonic resistance or act as a mechanical barrier against stress (Hinata & Murakami, 2014). The IAS is a smooth muscle, continuously active and is considered to be responsible for up to 85% of anal pressure at rest (Dickinson, 1978). The EAS is on the other hand a striated muscle and has primarily small type I muscle fibers and appears to be without muscle spindles (Schrøder & Reske-Nielsen, 1983). This information on the distribution of fast and slow twitch fibers is, however, based on old studies that depended on old technology. Further studies are needed with more sophisticated methodology.

1.1.2.2 Muscle function

The PFM have both tonic and phasic activity. At rest, tonic activity is present in both sphincters and the pubococcygeus muscles, even during sleep (Chantraine, 1973; Deindl, Vodusek, Hesse, & Schussler, 1993; Vodušek, 2015). This activity is important for preserving tone over a long period of time, adding to urethral and anal closure and unload weight of the fascias and ligaments. This constant activity is considered to derive from a spinal sacral center (Parks, Porter, & Melzak, 1962). Bladder filling is associated with an increase in tonic activity and during micturition there is a decrease in tonic activity of the pubococcygeus muscles and a relaxation of the striated urethral sphincter and the PFM (Deindl et al., 1993; Vodušek, 2015). Contraction of the PFM involves all the muscles as one functional unit. This creates a squeeze around the pelvic opening and a cranial and ventral movement (Bø, Lilleås, Talseth, & Hedland, 2001; Kegel, 1948). Effective voluntary PFM contraction elevates the bladder neck, closes the urethra (Peschers et al., 2001) as well as increases the anorectal angle (Dickinson, 1978) and thus adding to urinary and anal continence. A voluntary contraction may press the urethra against the symphysis pubis adding to closure efficacy (Ashton-Miller & Delancey, 2007). Voluntary PFM contraction has also been found to co-activate the urethral wall striated muscles as well as abdominal, gluteal and hip adductor muscles (Bo & Stien, 1994; Madill & McLean, 2006). During an increase in IAP the healthy PFM reacts unconsciously with a contraction that seems to be pre-programmed and happening before activity in the abdominal muscles or a rise in the IAP (Sapsford & Hodges, 2001).The abundance of type I muscle fibers and the lack of muscle spindles in both the external urethral and EAS indicate that their main role is to sustain contraction over a longer period and to react when tension increases (Schrøder & Reske-Nielsen, 1983).

1.2 Pregnancy and childbirth

1.2.1 Pregnancy

Many studies confirm that changes to the pelvic floor structures begin in early pregnancy (Dietz, Eldridge, Grace, & Clarke, 2004; Meyer, Bachelard, & De Grandi, 1998; Staer-Jensen et al., 2015; Stær-Jensen, Siafarikas, Hilde, Bø, & Engh, 2013; Van Geelen, Ostergard, & Sand, 2018).

Increased bladder and urethral mobility as compared to the non-pregnant state has been described as early as during the first trimester. The findings were in line with measured values of hyperextension of the elbow of the

same women, suggesting hormonal influences on connective tissues during pregnancy (Dietz et al., 2004). Maximal urethral closure pressures have also been found to be diminished during pregnancy (Meyer et al., 1998). An increase in LH diameters has been reported as well from mid- to late pregnancy, both at rest and during the Valsalva movement. The same study confirmed increased bladder neck mobility during pregnancy (Stær-Jensen et al., 2013). The influence of pregnancy on soft tissue was confirmed by another study in which the mean LH area was found to diminish postpartum in women going through cesarean section (CS) suggesting that changes could also be related to pregnancy (Shek & Dietz, 2009). Changes in the properties of pelvic floor tissues during pregnancy prepare the area for the forces of delivery and minimize the risk of ruptures (Ashton-Miller & DeLancey, 2009). In most pregnancies, increased abdominal weight is likely to influence posture, mostly in the lumbo-pelvic area, as well as to influence balance (Catena, Connolly, McGeorge, & Campbell, 2018; Haddox, Hausselle, & Azoug, 2020).

1.2.2 Vaginal delivery

Vaginal delivery (VD) has been considered to be the strongest factor in weakening the PFM and causing long-term PFD (Allen, Hosker, Smith, & Warrell, 1990; Borello-France et al., 2006; M. Gyhagen, Bullarbo, Nielsen, & Milsom, 2013a; Marshall, Walsh, & Baxter, 2002; Rortveit, Daltveit, Hannestad, & Hunskaar, 2003; Volloyhaug, Morkved, Salvesen, & Salvesen, 2015). The mechanism of VD is always a multifactorial event and therefore it can be difficult to determine the influences of each delivery factor on the outcomes of the pelvic floor.

At the initiation of the second stage of labor, considerable forces during the first stage have driven the fetal head through the cervix and into contact with the pelvic floor (Ashton-Miller & DeLancey, 2009). During the second stage, the stretch ratio of the pubococcygeus muscle has been estimated to be three fold (tissue length during stretch/resting tissue length), but less in the more lateral and distal parts of the levator ani muscle (Lien, Mooney, DeLancey, & Ashton-Miller, 2004) (Figure 2). Studies indicate that different branches of the pudendal nerve may stretch by up to 35% during pushing in the second stage (Lien, Morgan, DeLancey, & Ashton-Miller, 2005). Pudendal nerve damage may happen during this stage, with pressure from the fetal head along with stretching of both the muscles and nerves combined with simultaneous ischemia in the pelvic floor tissues (Conner et al., 2006; Jou, Lai, Shen, & Yamano, 2000; Lien et al., 2005; Sultan, Kamm, & Hudson, 1994).

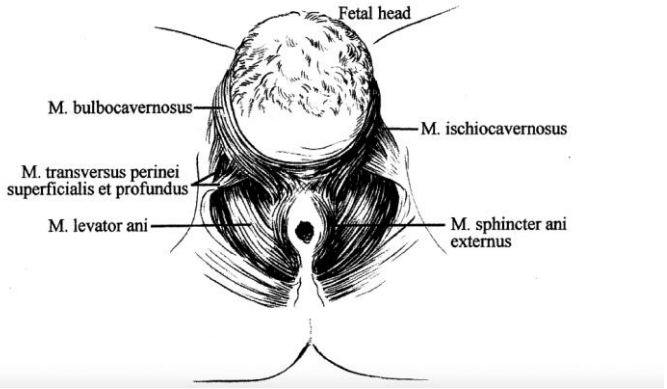

Figure 2. The fetal head crowning. Reprinted from: Baessler, K., & Schuessler, B. (2003). Childbirth-induced trauma to the urethral continence mechanism: review and recommendations. *Urology*, *62*(4 Suppl 1), 39–44. Copyright (2020) with permission from Elsevier.

Damage to the levator ani muscles has been detected after VD (de Araujo, Coelho, Stahlschmidt, & Juliato, 2018). This can involve avulsions from the attachments of the muscles onto the bony pelvis (Dietz & Lanzarone, 2005; Urbankova et al., 2019) and injury in the form of perineal tears, extending from the vagina as far as the anal sphincter complex, partially or completely (Andrews, Sultan, Thakar, & Jones, 2006; Dietz, Gillespie, & Phadke, 2007; Dudding, Vaizey, & Kamm, 2008). Studies have shown that the LH becomes larger after VD during rest, Valsalva and squeeze efforts (Toozs-Hobson, Balmforth, Cardozo, Khullar, & Athanasiou, 2008). This is even more marked in women suffering levator ani trauma such as avulsions during VD (Shek & Dietz, 2009). Staer-Jensen et al (2015) found a decrease in all measurements of the LH at rest, during contraction of the PFM and during Valsalva of women having VD, when comparing data during the first 6 months postpartum with that from during pregnancy. One year after the first delivery, the only difference still found between VD and CS was seen for the LH during contraction of the PFM (Staer-Jensen et al., 2015). The same author group found that a smaller LH at rest and during the Valsalva maneuver at pregnancy was associated with major levator ani defects after VD (Siafarikas, Stær-Jensen, Hilde, Bø, & Ellström Engh, 2015).

1.2.2.1 Vaginal delivery and the pelvic floor muscles

Hilde et al (2012) studied pregnant women and found that during mid-pregnancy continent women had stronger and more enduring PFM than their incontinent counterparts, but no significant difference was found regarding

resting pressure of the PFM (Hilde, Stær-Jensen, Engh, Brækken, & Bø, 2012). In a cross-sectional study conducted 6 weeks postpartum women with levator ani defects were found to have almost 50% reduction in strength and endurance of the PFM when compared with women without such muscular defects (Hilde, Stær-Jensen, Siafarikas, Gjestland, et al., 2013). Another study showed that both the vaginal resting pressure and strength of the PFM measured as a squeeze pressure increased during pregnancy but diminished after childbirth, then again increased when time passed from the childbirth, reaching pre-delivery values one year postpartum. This was not different between modes of delivery (Elenskaia, Thakar, Sultan, Scheer, & Beggs, 2011). Meyer et al (1998) found, however, no differences in PFM strength with advancing pregnancy, when measured as squeeze pressure (Meyer et al., 1998).

The influence of VD on PFM function has been studied by several other authors. We demonstrated that women going through VD and instrumental VD lost more PFM strength and endurance due to delivery than women having CS when measured six weeks after a first delivery (Sigurdardottir, Steingrimsdottir, Arnason, & Bo, 2011). This was supported by another study where PFM values were measured at the same intervals, showing the same trends in PFM strength, endurance and in vaginal resting pressure when comparing VD, instrumental VD and CS (Hilde, Stær-Jensen, Siafarikas, Engh, et al., 2013). In a recent review article (Van Geelen et al., 2018) it was concluded that pregnancy, especially the first one, decreases PFM strength. These changes were more prominent after VD, however, the authors inferred that the impact of various obstetrical and neonatal variables was mostly transient (Van Geelen et al., 2018). The review concluded that in most women, PFM function recovers during the first postpartum year which concurs with Elenskaia et al. (Elenskaia et al., 2011).

Even though the current evidence points towards good recovery for most women after childbirth, which must be the evolutionary “normal”, researchers have shown that women who suffer from early postpartum symptoms of PFD are more likely to do so in the long run (Gartland, MacArthur, Woolhouse, McDonald, & Brown, 2015; Viktrup, Rortveit, & Lose, 2006). This underlines the need to detect these women soon after childbirth in order to give them the opportunity to address their concerns regarding PFD and to offer support.

1.3 Female pelvic floor dysfunction

Some women may be at increased risk of developing PFD during pregnancy

and after childbirth due to congenital or inherited connective tissue defects (Keane, Sims, Abrams, & Bailey, 1997). The prevalence of such symptoms seems to increase with age and parity as well (Mant, Painter, & Vessey, 1997; I. Nygaard et al., 2008). Higher age and parity as well as an increase in BMI often coincide with other co-morbidities and therefore age cannot be considered separately as an independent or "normal" factor for increase in PFD symptoms (Milsom et al., 2017).

DeLancey et al. (2008) explained (Figure 3) how genetic factors, i.e. the different functional reserves that each person develops during progression and maturation to adulthood, and the impact of inciting factors such as childbirth, has on the development of PFD. Finally the influences of aging and lifestyle can affect how, when and if symptoms appear (DeLancey, Kane Low, Miller, Patel, & Tumbarello, 2008). The model set forth by these authors describes well why some women develop pelvic floor symptoms and some not.

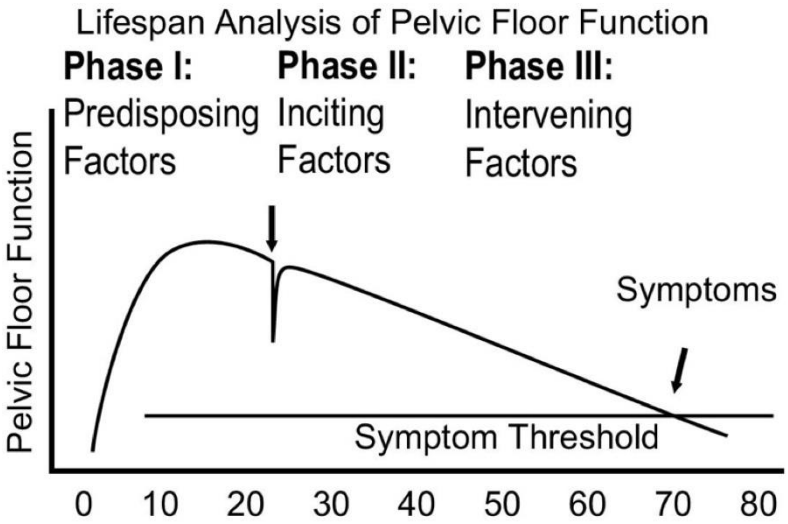

Figure 3. DeLancey´s model of integrated life span analysis of pelvic floor function. Reprinted from: DeLancey JO., Kane Low L, Miller JM, Patel DA, Tumbarello JA. Graphic integration of causal factors of pelvic floor disorders: an integrated life span model. Am J Obstet Gynecol 2008;199:610.e1-610.e5. Copyright (2020), with permission from Elsevier.

In a study on benign hypermobility syndrome and its influences on delivery outcomes and the risk of developing pelvic floor disorders, the authors found that benign hypermobility was associated with the likelihood of normal spontaneous vaginal delivery and lesser risk of operative delivery, emergency CS, prolonged second stage of labor and anal sphincter tears. However, increased risk for the development of postpartum PFD was not confirmed (Knoepp, McDermott, Muñoz, Blomquist, & Handa, 2013). On a different note, the results from Campeau et al. (2011) and Tezelli Bortolini & Rizk (2011) indicate a genetic link in the structure of tissues predisposing some women to UI and POP symptoms (Campeau, Gorbachinsky, Badlani, & Andersson, 2011; Tezelli Bortolini & Rizk, 2011). This was though disputed by Dietz (2012) where he argued that pelvic floor trauma during labor was the major risk factor for POP (Dietz, 2012).

Difficult VD with a combination of several obstetric events and procedures has been linked to higher rates of PFD (Memon & Handa, 2013). However, CS has not been found to be fully protective against PFD later in life (Chaliha, 2009; MacLennan, Taylor, Wilson, & Wilson, 2000; Milsom et al., 2017). Rørtveit and Hannestad (2014) supported this in their review where the findings indicated that CS is overall not protective against UI in middle-aged women, but the risk for pelvic organ prolapse (POP) increases with the number of VDs. They also stated that CS was not protective against anal incontinence (AI) in the long run, but women suffering anal sphincter ruptures during VD have an increased risk of AI (Rortveit & Hannestad, 2014). This has though been disputed by the studies of Gyhagen et al. who showed that after single VD compared with one CS, a higher prevalence of long-term urinary, POP and anal symptoms prevailed (Gyhagen, Bullarbo, Nielsen, & Milsom, 2013c, 2013b; Gyhagen, Bullarbo, Nielsen, & Milsom, 2014).

Many factors can, however, influence the rate of PFD in women. Those factors include hysterectomy and other genitourinary surgery, smoking, exercise, general mental and physical health or illness, diet, medication, socio-economic status and ethnicity (Milsom et al., 2017) and the presence of similar factors before pregnancy (Durnea et al., 2017).

1.3.1 Definitions, prevalence and risk factors for symptoms in the postpartum period

The terminology of the joint committees of the International Urogynecological Association (IUGA) and the International Continence Society (ICS) for the symptoms of female pelvic floor dysfunction is described in the book Incontinence (Abrams, Cardozo, Wagg, & Wein, 2017) in several chapters

along with an overview of the prevalence, risk factors and pathophysiology that have been studied with reference to these symptoms and the female pelvic organs (Dumoulin et al., 2017; Milsom et al., 2017; Salvatore et al., 2017).

1.3.1.1 Urinary incontinence

UI is defined as a complaint of involuntary loss of urine. It can also be further defined as observation of involuntary loss of urine on examination or formally diagnosed in a laboratory setting; i.e. stress urinary incontinence or detrusor overactivity confirmed with urodynamic testing (Haylen et al., 2010).

Stress urinary incontinence (SUI) is defined as a complaint of involuntary loss of urine on effort or physical exertion. Urgency urinary incontinence (UUI) is defined as a complaint of involuntary loss of urine associated with urgency. Mixed urinary incontinence is defined as a combination of the above mentioned (Milsom et al., 2017).

Coital urinary incontinence is defined as the loss of urine occurring before, during or after vaginal intercourse (Haylen et al., 2010).

Other subtypes of incontinence in adults have been defined, but will only be mentioned here as they were not the object of the studies for the thesis: adult nocturnal enuresis, postural incontinence, continuous incontinence, insensible incontinence and functional incontinence (Abrams et al., 2017).

The prevalence of postpartum UI (i.e. during the first weeks following childbirth) is high, but lower than during late pregnancy. Studies have reported rates of up to 30%, with SUI being more prevalent in this period than UUI and multiparous women being more affected. Consensus from several studies described the most dominant risk factors as parity, high maternal BMI and age, UI before and during pregnancy, VD, operative VD, perineal or anal sphincter trauma and high birthweight of the newborn (Milsom et al., 2017) (Woodley, Boyle, Cody, Morkved, & Hay-Smith, 2017).

1.3.1.2 Anal incontinence

Equally, fecal incontinence is the involuntary loss of feces, solid or liquid. Flatus incontinence is the involuntary loss of flatus or wind. Collectively, these conditions are named anal incontinence (AI) (Haylen et al., 2010).

Postpartum AI, including fecal and flatus incontinence, can be difficult to estimate as women may in some cultural settings be hesitant to talk about this condition. In primiparous women the prevalence of fecal incontinence

appears to be much lower than that of UI, but when flatus incontinence is taken into account as well, the overall rates of AI are high in the early to mid-postpartum period. The cited rates can be as high as 46% for flatus and 8% of fecal incontinence. The strongest risk factor has been found to be anal sphincter rupture (Bols et al., 2010; Woodley et al., 2017). Cescon et al. (2014) reported potential damage to the innervation of the anal sphincter muscles as a result of medio-lateral episiotomy and emphasized the need for follow-up studies of women to find out if AI was likely to occur later in life among those affected (Cescon et al., 2014).

1.3.1.3 Pelvic organ prolapse

Pelvic organ prolapse (POP) is described as a loss of support for the vaginal walls, uterus, bladder, colon or rectum which results in partial and sometimes complete prolapse of one or more of these organs into or down through the vagina. The degree of POP is often referred to as being above, at or below the vaginal introitus (hymenal ring area).

Urinary and anal incontinence as well as POP can further be described by reference to the amount and frequency and also by their effect on quality of life for the woman affected (Bump et al., 1996; Haylen et al., 2010).

The prevalence of POP in the early postpartum period is relatively little reported. According to existing research, objective POP has been revealed in the early and mid-postpartum period after both VD and CS but seems to be more pronounced following VD. In the studies this was found to be more temporary for CS even though after one VD women seem in general to show good recovery from POP symptoms (Elenskaia, Thakar, Sultan, Scheer, & Onwude, 2013; O'Boyle, O'Boyle, Calhoun, & Davis, 2005; Reimers et al., 2016). POP symptoms in the immediate postpartum period have been found to be related to pre-labor maternal characteristics (Reimers et al., 2019). The prevalence of POP in the general female population has been reported to be up to 10% (Milsom et al., 2017). Later in life, POP has also been associated with thinner mothers, higher parity, higher birthweight, operative and instrumental VD, levator ani trauma and constipation (Abrams et al., 2017; Durnea et al., 2017; Memon & Handa, 2013; Rodriguez-Mias, Martinez-Franco, Aguado, Sanchez, & Amat-Tardiu, 2015).

1.3.1.4 Dyspareunia/pain during intercourse/coital pain

Sexual function and dysfunction in women involve many factors, is complex in nature and beyond the scope of this thesis. Female sexual dysfunction is traditionally described in relation to four main categories; desire, arousal,

orgasmic and sexual pain disorders (Basson et al., 2000). This study will focus mainly on the last, referred to as dyspareunia. Dyspareunia (pain during intercourse) is the complaint of pain or discomfort associated with attempted or completed vaginal introital penetration (Rogers et al., 2018).

Sexual dysfunction has been found to affect up to two-thirds of women in the postpartum period and nearly three-quarters have described some sexual dissatisfaction (Khajehei, Doherty, Tilley, & Sauer, 2015). Breastfeeding, low partnership quality, depression and having a CS has been correlated with sexual dysfunction (Chang, Lin, Lin, Shyu, & Lin, 2018; Matthies et al., 2019; Wallwiener et al., 2017) Pain during intercourse in the postpartum period has been related to difficult deliveries, i.e. perineal tears and perineal suturing, instrumental VD and emergency CS when compared to elective CS (Lipschuetz et al., 2015). McDonald et al. (2015) did, however, find elective CS to have increased odds of dyspareunia when compared to uncomplicated VD with an intact perineum (McDonald, Gartland, Small, & Brown, 2015). Many studies have confirmed that dyspareunia or pain during intercourse is strongly related to breastfeeding, mainly through vulvovaginal dryness caused by a lowered estrogenic status (Lagaert, Weyers, Van Kerrebroeck, & Elaut, 2017; Matthies et al., 2019). Tennfjord et al. (2014) found high prevalence of dyspareunia not only in the postpartum period but also before and during pregnancy. Women in their study reported the highest prevalence of this during the first six months postpartum. Reported bother (or a feeling of discomfort) from dyspareunia was also highest in the postpartum period. Dyspareunia was not related to any PFM parameters (Tennfjord et al., 2014).

The prevalence of PFD in the postpartum period has not been studied in Iceland. Birthweight is relatively high in the country (Landspítali/Landlæknir, 2009; Vidarsdottir, Geirsson, Hardardottir, Valdimarsdottir, & Dagbjartsson, 2011) and higher than in the other Nordic countries, perhaps excluding the Faroe Islands (Gamborg et al., 2007), and considerably higher than in the USA (Löfling, Bröms, Bahmanyar, & Kieler, 2016). A multinational summary by the World Health Organization revealed lower birthweight in the countries included than found in Iceland (Kiserud et al., 2018). Birthweight is one of the main risk factors for PFD (Milsom et al., 2017) and therefore it was of epidemiologic interest to study PFD among Icelandic postpartum women.

1.4 Conservative treatment of pelvic floor dysfunction in the postnatal period

1.4.1 How does pelvic floor muscle training work?

The pelvic floor muscles are striated skeletal muscles that are functionally and anatomically connected to some smooth muscle elements, such as the intrinsic urethral muscles and the IAS (Ashton-Miller & Delancey, 2007; Dickinson, 1978). In a review on how PFMT works Bo (2004) concluded that direct strength training of the PFM and conscious PFM pre-contractions during physical stress are the most likely methods to diminish or cure UI (Bo, 2004a). The principles of strength training can be applied to PFM as to other skeletal muscles (DiNubile, 1991; Garber et al., 2011). Chapter 1.1.2.2 describes the normal function of the PFM towards which training must be aimed at. Strength training of the PFM is likely to increase the cross-sectional area of the muscles and enhance neural adaptations, such as the number of active motor units and the frequency of excitation. Training should include overload, i.e. demand more than is normally required and be specific, i.e. to be directed to the function needed to improve as well as include progression and maintenance of improvement (DiNubile, 1991; Garber et al., 2011). In guidelines from the American College of Sports Medicine resistance or stengthening exercises were recommended to be executed at 60-70% intensity of one repetition maximum (RM) for less experienced exercisers, at ≥80% of 1RM for experienced strength trainers and at 40-50% of 1 RM for older persons. Repetitions should be 8-12 in each set and preferably 2-4 sets during 2 or 3 days a week (Garber et al., 2011). It has been confirmed that strength training of the PFM can improve the muscle volume, that is the thickness of the PFM, decrease the LH area, elevate the bladder neck and the rectum as well as shorten the PFM length, all of which are factors improving the support to the pelvic organs (Brækken, Majida, Engh, & Bø, 2010).

Another important factor in the pelvic floor is the strength of the connective tissue, which in theory can be improved along with strength training of the PFM, resulting in a thicker, stiffer and shorter pelvic floor sitting higher in the pelvis (Bo, 2004a). Bo and Stien (1994) showed a relation between PFM contractions and simultaneous activation of the striated urethral wall muscles, which can then result in increased strength of the latter during PFMT (Bo & Stien, 1994). Bo (2004) discussed the use of the “knack” (pre-contracting the PFM before physical stress like for a cough) (Miller, Ashton-Miller, & DeLancey, 1998) and how it might prevent leakage. Pre-

contracting the PFM before physical stress elevates and stabilizes the bladder neck and increases the urethral closure pressure and has the potential to counteract any increase in IAP and thus prevent lekage (Bo, 2004a). In another study, the effects of the „knack“ on the strength of a voluntary PFM contraction were measured and no effects found. UI and sexual function were not improved either (de Andrade et al., 2018). The training effects of the „knack“ can therefore be considered minimal or none, although learning to use it under critical circumstances can be useful. Using the „knack“ requires the person to contract the PFM correctly, but several studies have shown that a high proportion of women are not able to do so (Bo et al., 1988; Bump, Hurt, Fantl, & Wyman, 1991; Vermandel et al., 2014).

The importance of the anorectal angle for anal continence has been established (Dickinson, 1978). Training the puborectalis could therefore add to alleviating anal continence. With the connections between the puborectalis muscle and EAS, PFMT might also simultaneously strengthen the sphincter, although people are probably not aware of the difference of contracting either one of them or both (Norton & Cody, 2012). Muscle training in general and therefore also that of the PFM may influence strength, endurance, the speed of the contraction and help with coordination of muscle function, as well as add to motor learning (Bø & Mørkved, 2015).

1.4.2 Evidence about the value of postpartum pelvic floor muscle training

PFMT applied for treating UI in women has a 1A level of evidence level for success and is widely recommended as first-line treatment (Dumoulin et al., 2017; Dumoulin, Cacciari, & Hay-Smith, 2018). Success rates in randomized controlled trial (RCT) studies have differed somewhat, but are reported the reach up to 80% (Aksac et al., 2003; Dumoulin et al., 2004; Morkved, Bo, & Fjortoft, 2002).

Morkved and Bo (1997) demonstrated good results in favor of postpartum PFMT in a study using matched pairs of women for prevention and treatment of UI (Morkved & Bo, 1997). However, reports of PFMT in the postpartum period have on the whole been conflicting and the authors of a Cochrane review called for more RCTs to further study the effects (Woodley et al., 2020). The review found some evidence that structured early-pregnancy PFMT might prevent UI later in pregnancy and postpartum. They also suggested that targeted, that is offering PFMT as a treatment for postpartum UI rather than population-based PFMT for both prevention and treatment,

could be more effective. They recommended as well that the effects of PFMT on AI in the postpartum period should be included in future studies, as such studies are scarce (Woodley et al., 2020). Some RCTs have though shown positive results of postpartum PFMT on AI in the late postnatal period (>6-12 months) (Glazener et al., 2001; Johannessen, Wibe, Stordahl, Sandvik, & Morkved, 2017).

The evidence regarding PFMT as a prevention or treatment for POP in the general female population is somewhat less than for UI. It has though been concluded that there is a 1 A level of evidence for positive effects of PFMT treatment on the severity of prolapse symptoms in women with grade I to III prolapse, as well as showing improved function of the PFM. The same publication claimed that there is a 1 B evidence on the preventive influence of PFMT on POP symptoms in adult women (Dumoulin et al., 2017). A systematic review reported that there was overall an efficacy of PFMT on subjective POP symptoms, as well as improvement in anatomical POP severity (Li, Gong, & Wang, 2016). In a recent study on peri-operative PFMT, no additional effect on POP symptoms or other outcomes in women undergoing POP surgery was, however, found that could be ascribed to training when evaluated in the first months after surgery (Duarte et al., 2020)

Few studies have focused on PFMT as a treatment for POP in the postpartum period. In a study from 2015, where participants were stratified on the presence or absence of major levator ani defects, no effects of PFMT on different stages of POP, bladder neck position or on subjective symptoms were seen (Bo et al., 2015b). In another study, the severity of POP stages was significantly improved three months postpartum for both intervention groups. This was immediately after the treatment period which consisted of a) PFMT and b) PFMT along with vaginal electrical stimulation, compared to a control group (Yang et al., 2017).

Some studies have addressed postpartum PFMT for sexual dysfunctional symptoms. A systematic review concluded that PFMT in the postpartum period was likely to improve at least one factor of sexual function, including sexual desire, arousal, orgasm and satisfaction (Sobhgol, Priddis, Smith, & Dahlen, 2019). Tennfjord et al. (2016) found no overall differences between training and control groups regarding sexual dysfunction such as dyspareunia, coital incontinence, although a subgroup analysis showed that women with levator ani defects improved more than women with similar defects in the control group regarding “vagina feels loose or lax” when measured 6 months postpartum (Tennfjord et al., 2016).

There is still no complete consensus regarding the outcomes of PFMT for dysfunctional pelvic symptoms in postpartum women even though the available literature points towards positive outcomes for urinary symptoms. More evidence is needed in the field and as well, for anal, prolapse and sexual dysfunctional symptoms that have scarcely been studied and results from the existing RCTs are quite controversial.

1.5 Participation in sports and childbirth

General guidelines recommend healthy pregnant women to continue or to commence physical activity and exercise during pregnancy and after childbirth, as well as to practice PFMT ("ACOG Committee Opinion No. 650: Physical Activity and Exercise During Pregnancy and the Postpartum Period," 2015; "Physical Activity and Exercise During Pregnancy and the Postpartum Period: ACOG Committee Opinion, Number 804," 2020; Boyle, Hay-Smith, Cody, & Morkved, 2012; Evenson, Mottola, Owe, Rousham, & Brown, 2014; Mottola et al., 2018).

In the case of the elite athlete, the motivation for staying fit is strong and a return to competition soon after childbirth is probably a goal for most female professional athletes. The amount of recommended physical activity for a pregnant non-athletic woman is almost certainly less that what is the typical dose for the competing athlete, and in particular the elite athlete.

High levels of training before and during pregnancy can raise questions for the pregnant athletes, their trainers and caregivers on how training may possibly influence the pregnancy and not least the childbirth and how childbirth affects return to practice and competition. One case-study from 2018 reported intense and frequent training during pregnancy and return to exercise early after childbirth of one of the world´s most successful cross-country skier. The study revealed great tolerance for high doses of training during pregnancy followed by an effective return to competition (Solli & Sandbakk, 2018). In a recently published cohort study (2020) the influences of moderate to vigorous physical activity soon after the first vaginal birth was objectively measured one year postpartum. The authors found that moderate physical activity was either protective or had no effect on UI and other aspects of pelvic health except for POP symptoms, which became worse when compared to more light physical activity. No conclusions could be drawn regarding vigorous exercises as few participants reported training like that (Nygaard, Wolpern, Bardsley, Egger, & Shaw, 2020).

General physical activity or regular exercise during pregnancy has been found to have no effect on the progress of labor or to influence it in a favorable or unfavorable way. This applied to factors including the length of the second stage of labor, the rate of emergency CS and serious levator ani, perineal or anal sphincter injury. No studies had been done on elite athletes regarding these outcomes (Bo et al., 2016; Haakstad & Bø, 2020) prior to the study published as part of this thesis (Sigurdardottir et al., 2019).

There is some evidence supporting that PFMT does not in general influence the progress of labor negatively (Bø & Nygaard, 2020). Several studies have shown that female athletes involved in competition have similar or even lesser PFM strength than non-athletes (Borin, Nunes, & Guirro, 2013; Figuers, Boyle, Caprio, & Weidner, 2008; Ludviksdottir, Hardardottir, Sigurdardottir, & Ulfarsson, 2018). This suggests that strenuous training does not necessarily strengthen the pelvic floor at the same time as other striated muscles. There are though other studies showing results to the contrary (Bø & Nygaard, 2020). A study involving regular female exercisers who were not competing athletes, reported them to have stronger PFM than non-exercisers during pregnancy (Bø, Ellstrøm Engh, & Hilde, 2018). It can be assumed that elite athletes need a stronger and more responsive PFM than other women in order to withstand the physical strain accompanied by many sports which include rapid increases in IAP during various maneuvers, such as heavy lifting, jumping and landing (Bo, 2004b).

Several studies have shown that there is a high prevalence of UI among nulliparous female athletes, which can be an indication of a prior weak pelvic floor, a lack of muscle coordination or delayed timing of the PFM contraction in relation to the impact created by the athletic performance (Bo & Borgen, 2001; Carvalhais, Natal Jorge, & Bø, 2018; Moser, Leitner, Baeyens, & Radlinger, 2018; Nygaard, Thompson, Svengalis, & Albright, 1994; Thyssen, Clevin, Olesen, & Lose, 2002). The logical response would be to create specific training efforts to forestall such uncomfortable events in sports.

Kruger et al. (2005 and 2007) studied nulliparous high-impact female athletes with magnetic resonance imaging of the PFM. The athletes in the study had thicker PFM than seen in the control group. This could have ascribed to a selection bias since athletes in general have thicker muscles (Suchomel, Nimphius, Bellon, & Stone, 2018). Kruger et al. (2005) concluded that this could result in difficulties during childbirth. This claim was, however, based on nulliparous participants and was not confirmed by actual delivery information. The authors suggested that more research was needed to look

into this (Kruger et al., 2007; Kruger, Murphy, & Heap, 2005). In general it may be said that there is a lack of published studies regarding the outcomes of PFMT among elite female athletes and on the impact of participation in competitive sports on childbirth (Bo et al., 2016).

Elite female athletes have been reported to have higher rates of urinary incontinence compared to other women. However they can also be expected to have an overall increased muscle mass, also in their pelvic floor. This inspired my desire to include their childbirth outcomes in this doctoral study. If discovering worse delivery outcomes for the pelvic floor among athletic women had been found, then this would have revealed a need for more follow-up and advice for this group of women who often return to sports soon after childbirth.

2 Aims

The overall objective of this doctoral study was to add to knowledge about the prevalence of pelvic floor dysfunction and bother related to this, and to investigate associations with delivery factors, in first-time mothers during the first months after birth. Another main objective was to study the influences of early physical therapy intervention on pelvic floor symptoms and bother from them. A third goal was to study the influence of pre-delivery physical stress among athletes on childbirth outcomes.

2.1 Specific aims

Study I

To investigate the prevalence of pelvic floor dysfunction and related bother in primiparas going through either vaginal or cesarean delivery, 6-10 weeks postpartum. A secondary aim was to associate PFD with delivery factors.

Study II

To study the effects of individualized, physical therapist-guided postpartum pelvic floor muscle training on the rates of urinary and anal incontinence and related bother in first-time mothers, as well as on pelvic floor muscle strength and endurance. Outcomes were measured after the intervention which consisted of 12 weekly sessions and at follow-up, one year postpartum.

Study III

To compare delivery outcomes in a first childbirth between elite female athletes who participated in either high- or low-impact sports, using as a control group women who were only physically active at a recreational level. Furthermore, to study the association between delivery outcomes and exercise training frequency before and during the first pregnancy in elite athletes.

2.2 Hypotheses tested

Study I

Women going through vaginal delivery experience more often postpartum pelvic floor dysfunctions and more bothersome symptoms in the second month after the first childbirth than women having a cesarean delivery.

Study II

Women who receive pelvic floor muscle training in the early postpartum period have lower rates of urinary and anal incontinence and experience lower rates of related bother after the training period than a control group.

Women in the intervention group have stronger and more enduring pelvic floor muscles after the training period than women in the control group.

Women receiving pelvic floor muscle training have lower rates of urinary and anal incontinence and related bother half a year after the cessation of the intervention (one year after the childbirth).

Women in the intervention group still have stronger and more enduring pelvic floor muscles than women in the control group half a year after the cessation of the intervention (one year after the childbirth).

Study III

Elite female athletes, either from high- or low-impact sports, do not experience more complicated childbirth than non-athletes.

The frequency of training of elite female athletes before and during the first pregnancy does not show associations with delivery outcomes.

3 Materials and methods

In this chapter, the materials and methods applied in the research for this thesis are described. For more details of the methodology, Articles I, II and III are provided as part of the dissertation. Table 1 provides an overview of the participants and study methods.

Table 1. Overview of the research designs, settings and samples for Studies I, II and III

	Study I Observational study	Study II Intervention study (RCT)	Study III Observational study
Research design	Cross-sectional design	Assessor-blinded randomized controlled trial, parallel group design	Retrospective case-control design
Setting	Recruitment at Department of Obstetrics, Landspitali University Hospital	Outpatient physical therapy clinic	None, electronic participation
Sample	721 first-time mothers	84 first-time mothers Cases (n=41) Controls (n=43)	248 women Cases (n= 130) elite athletes Controls (n=118) non-competition women
Participants	Age 18-47 years Mean age 27	Age 20-44 years Mean age 28	Age 20-41 years at the time of first childbirth Mean age 27
Intervention		Cases: 12 PFM training sessions supervised by PTs beginning 6_{th}-13_{th} week postpartum ending ~6 months postpartum. Encouragement to exercise daily at home and exercise diary. Controls: None, not discouraged to exercise PFM	
Data collection	Questionnaire about PFD sent by e-mail 6-10 weeks after first childbirth. Closed at 10 weeks postpartum	Questionnaire about PFD sent by e-mail 6-10 weeks after first childbirth, also answered at endpoint and follow-up. Questionnaire about PFM exercises answered at follow-up. PFM- and anal sphincter measurements at baseline, endpoint and follow-up	Questionnaire about physical activity and sports sent by e-mail, answered retrospectively
Additional data	Maternal and obstetric data from the Icelandic Medical Birth Register	Maternal and obstetric data from the Icelandic Medical Birth Register	Maternal and obstetric data from the Icelandic Medical Birth Register as well as scanned foreign medical birth records

PFM; pelvic floor muscles, PFD; pelvic floor dysfunction

3.1 Study I

3.1.1 Design

Study I was a cross-sectional study where a sample of first-time mothers answered an online questionnaire about self-reported postpartum PFD. The replies were then linked to delivery data.

3.1.2 Recruitment and participants

Women were recruited at the maternity ward, Landspitali University Hospital, Reykjavik, from April 2015 to March 2017. The participants had to be at least 18 years of age and able to understand Icelandic. Exclusions criteria were: stillbirth, multiple birth, delivery before the 28th gestational week or having an otherwise unwell newborn, pre-existing diseases and conditions likely to predispose to pelvic floor symptoms. This included bladder or bowel diseases, neurological, psychiatric and cognitive disabilities possibly influencing women´s ability to handle a request to answer an online questionnaire.

3.1.3 Data collection

3.1.3.1 The Australian Pelvic Floor Questionnaire

The Australian Pelvic Floor Questionnaire (Icelandic translation) was used in Study I and II (Baessler, O'Neill, Maher, & Battistutta, 2010), (Appendices 1 and 2 show the English and the Icelandic versions). The questionnaire had been translated and pretested in advance by methods described by Beaton et al. (Beaton, Bombardier, Guillemin, & Ferraz, 2000), but not separately validated. Approval from the authors was obtained before the translation process. This questionnaire was chosen because it covers the main symptom categories of the pelvic floor in one questionnaire: bladder-, bowel- and prolapse symptoms as well as aspects of sexual function. The bladder section includes 15 questions, the bowel section 12 questions, the prolapse section 5 questions and the section for sexual function has 10 questions (women who report they are not sexually active answered only three questions). Symptoms of urinary, flatus and fecal (liquid or solid) incontinence were defined by frequency of leakage. All domains included questions about bother related to each category. The participants answered the whole questionnaire and returned their answers online. The English version had good test-retest reliability, was sensitive to change and had good construct validity and internal consistency (Baessler et al., 2010) Additionally to English the questionnaire has also been tested for psychometric properties in several other languages and populations (Argirović et al., 2014; Hou & Hou, 2020; Sarıibrahim Astepe & Köleli, 2019).

In Study I and Study II, answering "never" was considered a sign of no symptoms. Main questions used in the analysis were, for UI "Does urine leak when you rush or hurry to the toilet? Do you not make it in time?" and "Do you leak with coughing, sneezing, laughing or exercising?" This was also

used to distinguish between urgency and stress urinary incontinence. For AI the questions; “When you get wind or flatus, can you control it or does wind leak?“, “Do you leak watery stool when you don´t mean to?“ and “Do you leak normal stool when you don´t mean to?“. Regarding POP symptoms we used the questions; “Do you have a sensation of tissue protrusion or a lump or bulging in your vagina?“ and “Do you experience vaginal pressure or heaviness or a dragging sensation?“ as a sign of POP. On the subject of sexual function we used the questions: “Are you sexually active?“, “Do you experience pain with sexual intercourse?“ and “Do you leak urine during sexual intercourse?“ Answers of “occasionally, frequently and daily“ were all considered positive signs of UI and AI, POP, coital incontinence and/or pain during intercourse.

Bother from all categories was considered nonexistent if answering “not at all“ or “not applicable, I do not have a problem“ to the questions; “How much does your bladder problem bother you?“, “How much does your bowel problem bother you?“, “How much does your prolapse problem bother you?“ and “How much do these sexual issues bother you?“. Answers of “slightly, moderately and greatly“ were all considered indications of bother.

According to this approach, data was analyzed as from two categories, 0= no symptoms or no bother and 1=signs of symptoms and/or of bother.

Questions in the questionnaire have different scores, either 0-1, 0-2 or 0-3. Total domain scores attainable for each domain were calculated into the range 0-10, where a higher total score indicated more symptoms and bother.

An e-mail with a weblink to the questionnaire and comprehensive information regarding the study was sent to the participants six weeks postpartum and kept active for four weeks after which it became inactive. Weekly reminder e-mails were sent up to three times. Thus, the results reflect on symptoms from 6 to 10 weeks after childbirth. Answering the questionnaire was considered equal to informed consent.

3.1.3.2 The birth register

Information from the electronic Icelandic Medical Birth Register was retrieved for the women who answered the questionnaire. This included maternal age (years), height (m), weight (kg), and body mass index (BMI) as kg/m^2 at the first antenatal visit, weight change during pregnancy, mode of delivery, duration of first and second stages of labor (hours), 3^{rd} and 4^{th} degree perineal tear, use of episiotomy, anesthesia/epidural, fetal presentation, birthweight (g), birth length and newborn head circumference (cm).

3.1.3.3 Outcome measures

Primary outcomes in Study I were the prevalence of PFD and bother experienced by the women in relation to each symptom domain and comparison between VD and CS. Secondary outcomes included analyses of possible maternal and delivery associated characteristics for postpartum PFD.

3.2 Study II

3.2.1 Design and setting

The effects of postpartum pelvic floor muscle training on the rate of urinary and anal incontinence in first-time mothers were investigated in an assessor-blinded, parallel-group RCT. The trial was carried out at Táp Physical Therapy Clinic in Kópavogur, Iceland, from March 2016 to January 2018.

3.2.2 Participants and randomization

During 2016-2017, a subsample of symptomatic participants from Study I were invited to take part in Study II. After screening the replies of the questionnaire for PFD as soon as they were returned, ninety-five eligible women were invited to participate through a telephone call. The selection of women invited to participate was based on the presence of postpartum symptoms of UI. AI was also classified as a primary outcome if present. Additionally, the women had to be geographically able to attend the treatment sessions and have the ability to contract their pelvic floor muscles as confirmed by vaginal palpation. The PhD candidate (main outcome assessor, Þ.S.) examined all participants at the beginning of the trial, before the randomization procedure, in order to maintain unity in the assessment. Information from the birth register had already been obtained in Study I.

After the initial examination the clinics' secretary randomly assigned the participants to either intervention or control groups using random sequence numbers from an online generator (https://stattrek.com/statistics/random-number-generator.aspx). A Microsoft Excel™ document including the randomization was secured with a password and only accessible to the secretary who was also in charge of booking participants for the endpoint and follow-up visits. The main assessor was blinded to group allocation throughout the study.

3.2.3 Measurements and instrumentation

3.2.3.1 Outcome measures

Rates of women suffering UI and AI, indicating changes in the status of self-reported UI, together with SUI, UUI and AI (fecal and/or flatus incontinence) from recruitment to endpoint (end of completed treatment) and follow-up (one year postpartum) were primary outcomes.

Secondary outcomes were rates of bother from both bladder and bowel symptoms as well as changes in PFM and anal sphincter strength and endurance.

Information and assessment of participants was obtained at recruitment, after completed treatment (endpoint) and finally one year postpartum (follow-up).

3.2.3.2 The Australian Pelvic Floor Questionnaire

The Icelandic translation of the Australian Pelvic Floor Questionnaire was used in this study as well as in Study I. Description of the questions used for the purpose of Study I and II is in chapter 3.1.3.1 and appendices 1 and 2. Study II only addressed urinary and anal symptoms and bother related to those symptoms.

3.2.3.3 Physical examination and measurements of the pelvic floor muscles

At baseline, the women were given instructions on how to perform a correct PFM contraction, which was verified with an observation and vaginal palpation of PFM contraction by the main outcome assessor (Bo & Finckenhagen, 2001; Bo, Kvarstein, Hagen, & Larsen, 1990a). Measurements of PFM function were then done with a manometer, the Myomed 932™ (Enraf Nonius, Netherlands), (Figure 4), first with vaginal and after that, anal air-pressure probes (Bo et al., 2017). Air pressure changes measured with vaginal (or anal) probes during PFM contractions have been used as a proxy for strength and endurance in several studies since Arnold Kegel introduced such a device in 1948 (Kegel, 1948). The device had been tested for test-retest intra-rater reliability and had an intraclass correlation coefficient of 0.97 ($p<0.001$) (Sigurdardottir, Steingrimsdottir, Arnason, & Bø, 2009). Manometry of PFM strength and endurance has been shown to be valid if simultaneous inward movement of the measuring probe during measurement is observed (Bo, Kvarstein, Hagen, & Larsen, 1990b). With the women lying in the lithotomy position, vaginal resting pressure, maximal

strength and endurance were measured. Subsequently, the same parameters for the anal sphincter muscles were assessed with the women lying on their left side.

Figure 4. Myomed 932™ from Enraf Nonius, the Netherlands. Manometer with vaginal and anal pressure sensors used to measure strength and endurance of the pelvic floor muscles and anal sphincters in Study II.

3.2.4 Intervention

The intervention consisted of the following components:

Individual sessions of pelvic floor muscle training supervised by two experienced women´s health physical therapists, both with knowledge of women´s health issues, particularly pelvic health.

A biofeedback device (NeuroTrack Simplex™, Quintet, Norway) with vaginal electromyographic (EMG) sensors, shown in Figure 5, was used for motivation of maximal contraction and progression of the training. The device could also be used to motivate women for relaxation of the pelvic floor muscles (Bo et al., 2017).

Instructions on relaxation of the PFM by diaphragmatic breathing between each contraction was given.

Each woman received twelve weekly sessions, each 45 to 60 minutes long. If the women cancelled, a new appointment was given to complete the 12 sessions.

The training protocol:

Detailed description of this is given in Article II. The training method was mostly adopted from the study of Morkved and Bo (1997) and was tailored to the ability of each woman but with a progress component built into the training protocol with step-wise increases in demand using a feedback device during the training period to encourage as much progress as possible. The women lay in a recumbent position during the PFM training (Morkved & Bo, 1997). The protocol encouraged the women to do 10 close to maximum contractions with 7 second holding periods (1 sec ramp up, 5 sec holding and 1 sec ramp down) and a 10 second rest between each contraction. In the first two appointments women were asked to do two sets with a rest in between and in the remaining sessions 3x10 contractions if possible. The women were encouraged to progress from session to session and relax their PFM by diaphragmatic breathing between each contraction. During sessions 8-9, the women were encouraged to add three fast contractions at the end of each contraction and do so in the remaining sessions (Morkved & Bo, 1997). Women in the intervention group were instructed to do home exercises of 10 close-to-maximum PFM contractions, three sets every day. They were also encouraged to use the “knack“ (pre-contracting the PFM before coughing and sneezing). The participants in the intervention group were handed an exercise diary to record adherence to the home program and asked how they managed to do home exercises every time they met the physical therapist (Appendices 3 and 4 show the English and the Icelandic versions).

The endpoint assessment was done within a week after the last of the 12 sessions and at a comparable time for the women in the control group. Follow-up assessment was planned for all participants one year postpartum. During the endpoint and follow-up, women answered the questionnaire again and PFM and anal muscle function were measured. During the follow-up, a separate questionnaire about PFMT adherence during the study period was answered.

Figure 5. Biofeedback device with vaginal sensor used in Study II from Quintet, Norway.

The controls received only general instructions on a correct PFM contraction to ensure valid measurements during the assessment of the PFM at baseline but were not discouraged from doing PFM exercises.

3.3 Study III

3.3.1 Design

The delivery outcomes of female elite athletes and non-athletic women were compared with physical activity and/or participation in sports from before and during first pregnancy and childbirth in a retrospective case-control study.

3.3.2 Participants and data collection

Due to the small Icelandic nation, elite female athletes who have given birth are easily recognized, traceable and contactable. They were mostly contacted directly and/or through a special Facebook™ page (https://www.facebook.com/groups/729493120478382/) made especially for this study. With the snowball sampling method, the athletes accepting to participate helped in recruiting more athletes in their sport and women to form the control group. Requests for women to join the control group were also mediated through Facebook. The elite athletes were grouped according to the nature of their sport, into low- and high-impact sports. High-impact sports include activity where both feet can be above the ground at the same time and most often involve physical stress when jumping and landing. Low-impact sports is when one or both feet are on the ground at all times or include minimal gravitational influence like swimming (Bø & Kamhaug, 1989).

The athletes had to participate in competitive sports in the highest division possible, i.e. be a member of a national team or to have been a professional athlete in their sport for at least three years before their first pregnancy. Participants in the non-athletic group could be physically active at a recreational level before and during their first pregnancy, but not competing in sports, thus representing the average woman.

Otherwise, inclusion criteria were a healthy mother, with singleton first pregnancy, able to understand Icelandic or English. Exclusion criteria were high-risk pregnancy, such as gestational hypertension, pre-eclampsia or multiple pregnancy.

Participants were contacted by telephone or an e-mail and afterwards sent information about the study with a weblink to a questionnaire through e-mail. Data were collected through one year, from November 2015 to October 2016.

3.3.2.1 The questionnaire

All participants answered an electronic questionnaire regarding their personal characteristics such as ID number and date of first childbirth, necessary information to identify the birth records, employment and education status and smoking, and type of physical activity, participation in sports, including frequency of training, both in their own competitive sport and on other regular training. This was classified by strength, endurance and/or flexibility training, number of years in the highest division possible and/or by membership in the national team before and during their first pregnancy (Appendix 5 and 6 show the English and Icelandic versions).

3.3.2.2 The birth register

The same information on pregnancy and childbirth outcomes were extracted from the Icelandic Medical Birth Register as in Study I and II, see chapter 3.1.3.2. Some older birth records lacked detailed information, especially regarding the length of stages of labor. The study team went through paper records to try and recover this information. Eleven athletes had delivered their first child in another country while being a professional athlete in their sport. They scanned and e-mailed their medical birth records to the study team.

3.4 Statistical analysis

In Study I and II SPSS version 24-26 software items (IBM Corp., Armonk,

NY, USA) were used for statistical analysis. In Study III SAS version 9.4, R and Stata version 14 software items were used for analysis of the data. In study II sample size calculation was based on a previous study where a 67% vs. 34% reduction in the prevalence of UI was found in the intervention and control groups (Morkved & Bo, 1997). With a power of 0.8 and two-sided significance of $p<0.05$, 40 women were thought to be needed in each group, accounting for a 5% dropout rate.

Conventional statistical methods were used regarding the descriptive analysis of characteristics of the participants in all studies. Counts (n) with percentages (%) were reported and normally distributed continuous variables were presented as means with standard deviations (SD) or 95% confidence intervals (95% CI). Skewed continuous variables, thereof first and second stages of labor, were reported with medians and 10^{th}-90^{th} percentiles. Study II was analyzed per protocol as no information regarding outcome measures was available for the dropout women after the initial appointment (n=4). Rates of incontinence and perception of bother as well as other nominal data like the prevalence of 3^{rd} and 4^{th} degree of perineal tears were analyzed by the chi-squared or the Fisher´s exact test. An independent sample *t*-test was used to compare differences between groups for normally distributed continuous variables like birthweight, maternal BMI, PFM strength and endurance. The Mann-Whitney *U* test was executed for stages of labor (Study II). In Study I, multiple binary logistic regression analysis showing odds ratio (OR) and the 95% CI was applied to estimate the association between symptoms of PFD and delivery characteristics.

In Study III the chi-squared test was used to compare delivery outcome for the rates of emergency CS and 3^{rd} and 4^{th} degree perineal tears and a Kruskal-Wallis test for length of first and second stages of labor for the three groups. Penalized multiple logistic regression analysis with the Firth small-sample bias-reduction method was applied to estimate the association with predictor variables and impact groups (Greenland, Mansournia, & Altman, 2016; Mansournia, Geroldinger, Greenland, & Heinze, 2018). ORs with 95% CIs were calculated for the 3^{rd} and 4^{th} degree perineal tears. The results from the three models were presented as (1) unadjusted, (2) adjusted for maternal age, BMI and training frequency, and (3) model 2 with additional adjustment for birthweight. P values ≤ 0.05 were considered as indicating significance in all studies.

3.5 Ethical issues and approval

All studies obtained prior ethical approval from the Icelandic National Bioethics Committee (Ref: VSN-13-189), the Data Protection Authority (Ref: 2014030475TS/--) and Landspitali University Hospital (Ref: 16. OB/ei). All participants were informed about the aims and the data collection in the relevant studies. Women who answered the questionnaires online in study I and III were considered to have given their informed consent by answering and returning the answers. Women taking part in study II gave written informed consent prior to participation. Study II was registered at https://register.clinicaltrials.gov (NCT02682212) and finalization of the study has been declared to Clincaltrials.gov. Studies were conducted in accordance with the Helsinki declaration on human experimentation.

4 Results

The main results of the three studies are presented in this chapter. Preliminary results from a secondary analysis of Study II is also presented. Figures and tables are mainly reproduced from the original publications. In-depth results are given in the respective publications, Articles I, II and III.

4.1 Study I – a cross-sectional study

In all, 721 of 858 women (84%) who initially agreed to participate returned their replies about PFD during postpartum weeks 6-10. The mean age of the participants was 27 years (range 18-47). Women in the cesarean delivery group were significantly older and heavier than women giving birth vaginally. Birthweight was higher in the VD group ($p<0.001$). Table 2 shows characteristics of the study participants and delivery outcomes. Three women in the obese BMI category (>30) lost weight during their pregnancy, from 1.7 to 3 kg. No information was available for the non-responders as return of the questionnaire was considered an informed consent.

4.1.1 Main results

Twelve percent of the women reported no symptoms. The prevalence of UI was overall 48% and 27% of all participants experience bladder symptoms as bothersome. The rate of AI was 60% (only flatus incontinence in 396/430 of cases) and 56% of all the women found bowel symptoms to be bothersome. Symptoms of POP were experienced by 29% and 13% of all the women reported bother from this. At this time after childbirth, 55% of the women reported to be sexually active. Of these, 66% reported pain during intercourse and 3% described coital urinary incontinence. Ten percent of women who were not yet sexually active described in an open-ended question they were afraid that intercourse would be painful. Of all participants, including women who were not sexually active, 48% found sexual issues to be bothersome.

All urinary symptoms and POP symptoms were more common among women who delivered vaginally than with CS. Anal symptoms and pain during intercourse were not different between delivery routes (Table 3). Women who had a VD were more likely to suffer from two different symptoms of PFD or more (59% of VD vs. 38% of CS women), while women going through CS were more likely to have no or only one symptom (64% of CS vs. 41% of VD women, $p<0.001$).

Table 2 Characteristics of study participants1. Presented as mean with SD or numbers (n) and %.

	All participants (n=721)	*Vaginal delivery (n=601)*	*Cesarean delivery (n=120)*	*P- value*[2]
Age at first antenatal visit (years)	27 (4.8)	27 (4.6)	29 (5.7)	0.002
BMI at first antenatal visit (kg/m^2)	26 (5.6)	25 (5.4)	28 (6.2)	0.007
BMI <25	57%	61%	39%	
BMI 25-≤30	23%	22%	28%	
BMI>30	20%	17%	33%	
Gestational length (weeks)	39.5 (1.6)	39.5 (1.4)	39.2 (2.2)	<0.001
New-born variables				
Birthweight (g)	3572 (557)	3575 (511)	3559 (748)	<0.001
Delivery variables				
Mode of delivery (%)				
Vaginal delivery (n=601)	***83%***			
Spontaneous vaginal delivery	67%			
Instrumental; vacuum and forceps	19%			
3rd and 4th degree perineal tears	8%			
Episiotomy	17%			
Epidural anesthesia	66%			
Length of 1st stage (hours)[3]	10 (3.75-18.25)			
Length of 2nd stage (hours)[3]	1.15 (0.38-3.39)			
Cesarean delivery (n=120)	***17%***			
Emergency[4]	14%			
Elective	3%			

[1] Independent samples t-test for continuous variables. [2] P-value for differences between vaginal and caesarean delivery. [3] Median with 10th-90th percentile. [4] 8% of women going through emergency cesarean delivery reached 2nd stage of labor, one of them after failed instrumental delivery.

Of women having a VD, obesity in early pregnancy was significantly associated with symptoms of UI and birthweight above 50th percentile was associated with UUI. AI was significantly associated with the use of episiotomy during VD. No specific delivery factor was associated with postpartum symptoms of PFD in women going through CS, however, women in the CS group were significantly older and with higher BMI values than women having VD (p<0.001 in both cases).

Table 3. Frequency of symptomatic women with pelvic floor dysfunction[1] 6-10 weeks postpartum.

	All participants (n=721)	*Vaginal delivery (n=601)*	*Cesarean delivery (n=120)*	*P- value*[2]
Urinary incontinence[3]	48%	52%	27%	<0.001
SUI	37%	40%	20%	<0.001
UUI	30%	32%	18%	0.002
Anal incontinence	60%	61%	58%	0.6
Flatus incontinence	55%	56%	55%	
Combination of flatus and fecal incontinence	5%	5%	3%	
Prolapse symptoms	29%	33%	12%	<0.001
Sexually active women	55%	53%	65%	0.03
Coital incontinence[4]	3%	3%	3%	1.0
Coital pain[4]	66%	68%	64%	0.5

[1] Answers based on Icelandic translation of the Australian Pelvic Floor Questionnaire (REF)
Analyzed by chi-squared test. Answers represent the number of women who did answer different questions (missing values were 1-4% of answers). [2] P-value for differences between vaginal and caesarean delivery. [3] Of women suffering UI, 132 had mixed UI (both SUI and UUI), 120 in the vaginal delivery group and 12 from the cesarean section group. SUI, stress urinary incontinence; UUI, urgency urinary incontinence. [4] Of sexually active women.

4.1.2 Domain scores according to mode of delivery

By analyzing the original scores for every question in each domain of the questionnaire according to mode of delivery, a significant difference was evident between the groups in the scores pertaining to bladder function, prolapse and the sexual domain, with higher scores seen in the VD group in all cases. No difference between groups was observed in the bowel domain (Table 4).

Table 4. Scores according to individual symptom category for women with vaginal delivery and cesarean section. The Australian Pelvic Floor Questionnaire grades each domain of pelvic floor symptoms, where scores from all questions in the domains are added and calculated as 0-10. Higher scores signify more symptoms.

	Vaginal delivery mean (95% CI)	*Cesarean section mean (95% CI)*	*P-value*
Total scores - bladder domain*	1.05 (0.97-1.13)	0.73 (0.58-0.88)	0.001
Total scores - bowel domain*	1.99 (1.91-2.08)	1.82 (1.66-1.99)	0.108
Total scores - prolapse domain*	0.64 (0.54-0.73)	0.15 (0.07-0.23)	<0.001
Total scores - sexual domain*	1.79 (1.59-1.99)	1.23 (0.93-1.53)	0.020

*Independent samples t-test

4.2 Study II – an assessor-blinded randomized controlled trial

In total, 84 women were included, 41 for the intervention group and 43 controls. Four women (three and one from the intervention and control group respectively) withdrew from the study after the initial appointment. Collecting further data regarding outcome measures for the endpoint and follow-up was not achievable for the women who withdrew their participation. The trial started on average nine weeks postpartum. In Figure 6 it is shown how the participants contributed to the data collection throughout the study. All women who attended the intervention completed all 12 sessions with the physical therapist. Duration of the intervention period was on average 3.7 months (SD 0.7).

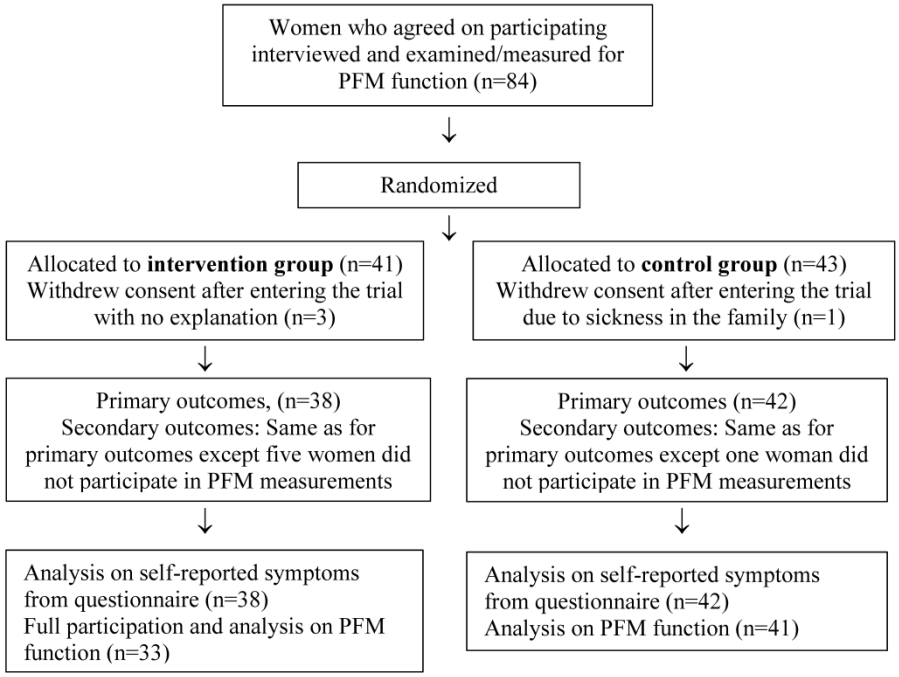

Figure 6 CONSORT flow diagram of participants throughout Study II

All participants were urine incontinent on recruitment, and 53/84 had symptoms of AI, i.e. 22 (67%) in the intervention group and 31 (76%) of the controls (p=0.44). Results for primary and secondary outcomes at endpoint are shown in Table 5. The intervention influenced the rate of UI significantly. At the end of the trial (~6 months postpartum), fewer women, 21 (57%) were urinary incontinent in the intervention group compared with 31 (82%) among the controls (p=0.03).

The intervention did not influence the rate of AI among the participants with 21 (58%) of the intervention and 27 (71%) of controls suffering from anal incontinence at endpoint (p=0.33).

Bladder- and bowel-related bother was similar between the groups at recruitment. At endpoint significantly fewer women from the intervention group reported bothersome bladder symptoms compared to the controls (27% vs. 60%, p=0.005).

The rate of bother from bowel symptoms at endpoint was not significantly different between groups (47% from the intervention vs. 51% controls, p=0.83).

PFM- and anal sphincter strength and endurance were not different between the groups at recruitment. The women in the intervention group had on average increased their PFM- strength and endurance significantly more than the control group at endpoint. This applied also to the anal sphincter strength and endurance variables (Table 5).

Table 5. Primary and secondary outcomes at endpoint 6 months postpartum.

	intervention/control (n)*	*Intervention group*	*Control group*	*P- value***
Outcomes at endpoints		***n (%)***	***n (%)***	
Urinary incontinence[1], n (%)	37/38	21 (57%)	31 (82%)	0.03
Bothered by urinary symptoms[1], n (%)	37/38	10 (27%)	23 (60%)	0.005
PFM strength[2], mean (SD)	33/38	29 (14)	24 (13)	0.003
PFM endurance[2], mean (SD)	33/38	234 (122)	180 (117)	0.001
Anal incontinence[1], n (%)	36/38	21 (58%)	27 (71%)	0.33
Bothered by bowel symptoms[1], n (%)	36/37	17 (47%)	19 (51%)	0.83
Anal sphincter strength[2], mean (SD)	33/37	84 (31)	71 (34)	0.01
Anal sphincter endurance[2], mean (SD)	33/37	578 (272)	450 (237)	0.02

[1] Fisher´s exact test, [2] Independent samples *t*-test. Strength of PFM and anal sphincters is measured as squeeze pressure in hPa. Endurance of PFM and anal sphincters is in hPa/sec. * Different number of women participated in PFM and anal sphincter measurements and some did not answer all questions in the questionnaire. ** P-values for PFM and anal strength and endurance at endpoint show significant changes from recruitment to endpoint.

Table 6 Primary and secondary outcomes at follow-up 12 months postpartum.

	intervention/control* ***(n)***	***Intervention group***	***Control group***	***P- value*** **
Outcomes at follow-up		***n (%)***	***n (%)***	
Urinary incontinence[1], n (%)	38/42	28 (76%)	34 (81%)	0.60
Bothered by urinary symptoms[1], n (%)	38/42	17 (45%)	17 (41%)	0.82
PFM strength[2], mean (SD)	33/41	32 (15)	27 (14)	0.03
PFM endurance[2], mean (SD)	33/41	255 (130)	201 (116)	0.002
Anal incontinence[1], n (%)	38/42	23 (60%)	26 (62%)	1.00
Bothered by bowel symptoms[1], n (%)	38/42	11 (29%)	20 (48%)	0.11
Anal sphincter strength[2], mean (SD)	33/40	91 (34)	77 (35)	0.008
Anal sphincter endurance[2], mean (SD)	33/40	618 (267)	504 (266)	0.04

[1] Fisher´s exact test, [2] Independent samples *t*-test. Strength of PFM and anal sphincters is measured as squeeze pressure in hPa. Endurance of PFM and anal sphincters is in hPa/sec. * Different number of women participated in PFM and anal sphincter measurements. Some did not answer all questions in the questionnaire. ** P-values for PFM and anal strength and endurance show significant changes from recruitment to follow-up

At the 12-month follow-up the difference between groups in the rate of UI had disappeared and the rate of AI was not different between groups either. Bother from bladder or bowel symptoms was similarly not different between groups. Both groups increased their PFM- and anal sphincter strength and endurance in a similar way from endpoint to follow-up, resulting in the intervention group still having better PFM- and anal strength and endurance at one year postpartum (Table 6).

Regarding the documentation of adherence to PFMT during the trial period, only 33% of the women returned their exercise diary at endpoint. They reported doing 10 PFM exercises from 1-4 times/day and for at least 3 days/week during the intervention. In the other cases, the diary was lost or the women forgot to document the exercise adherence.

At the one-year follow-up, 42 women in the control group (100%) reported retrospectively about PFM exercises and 19% of them had exercised ≥3 times/week from recruitment to endpoint (6 months), others less or not. From endpoint to follow-up, 14% of the controls continued exercising ≥3 times/week. Of the women in the intervention group 26% reported PFM exercises ≥3 times/week from endpoint to follow-up

4.2.1 Secondary analysis of results from Study II

Preliminary results from the RCT presented in Study and Article II indicated that the rate of women with POP symptoms in the early postpartum period was not influenced by the PFMT intervention when assessed immediately after the training session. Overall, the percentage of women reporting POP symptoms diminished during the first year postpartum. At recruitment, 39.5% of the women reported some degree of POP symptoms (42.5% for intervention group and 36.6% for the control group). After the intervention, (~6 months postpartum) 15% of them still had symptoms and at follow-up (one year postpartum) the prevalence was down to 12.5%.

Between endpoint and follow-up, women in the intervention group continued to improve and the rate of POP symptoms continued to go down (22.2% changed to 10.5%), but women in the control group had higher rates of the symptoms at follow-up (14.3%) than directly after the intervention (7.9%). These changes did, however, not reach significance. The participants in the study reported mostly mild symptoms. Correspondingly the rate of women in the intervention group who reported to be bothered to some degree remained similar at recruitment (13.2%) and endpoint (13.9%), but the rate had decreased at follow-up (2.7%). The women in the control group had a

much lower rate of bother at endpoint (2.6%) than at recruitment (21.4%), but the rate went up and was higher than for the intervention group at follow-up (7.1%). No inter-group comparisons reached significance (Figure 7).

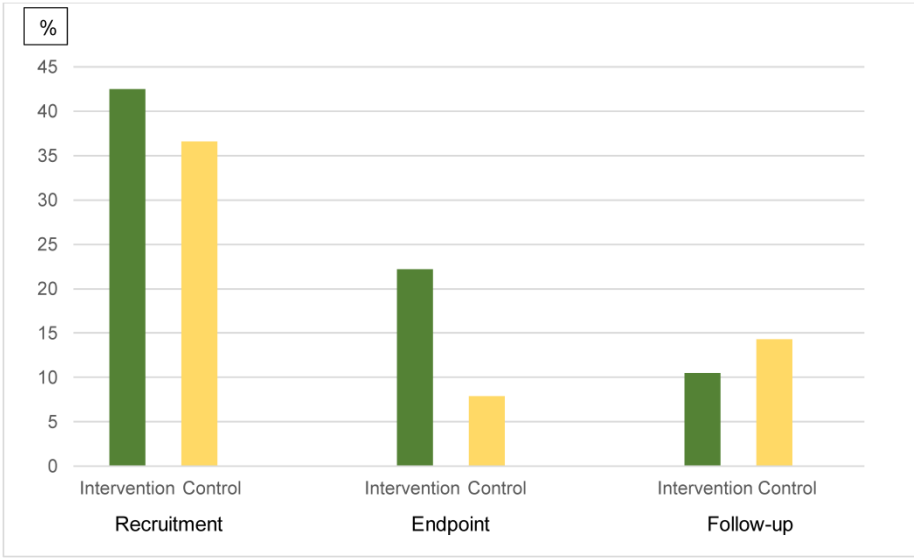

Figure 7. Prevalence of pelvic organ prolapse symptoms among participants in study II.

4.3 Study III – a retrospective case-control study

In total, 248 women participated by answering and returning the questionnaire, of whom 118 were non-athletes, 41 and 89 were low-impact and high-impact athletes respectively. Table 7 shows the characteristics of women particpating in the study and their exercise habits before and during pregnancy.

Table 8 shows delivery outcomes for the study groups as well as associations with predictive variables. There was one elective CS in each group. For comparison of delivery outcomes between groups these women were not included.

Table 7 Characteristics and past exercise habits (specific sports women engage in and additional training) at recruitment of study participants, presented for each period separately (means and SD).

	Non-athletics (n=118)	Low impact (n=41)	High impact (n=89)	p-value
Maternal				
Age at delivery (years)	26.0 (4.0)	26.7 (4.2)	27.2 (3.6)	0.21
Pre-pregnancy BMI (kg/m^2)	25.5 (5.7)	23.6 (3.0)	22.7 (2.8)	<0.001
Height (cm)	168.8 (6.5)	170.0 (6.6)	169.9 (6.1)	0.40
Neonatal				
Birthweight (kg)	3.5 (0.6)	3.7 (0.4)	3.6 (0.5)	0.02
Head circumference (cm)	35.1 (2.1)	36.0 (1.3)	35.6 (1.3)	0.009
Training				
Time from delivery to replies (years)	3.4 (15.0)	5.4 (16.7)	3.3 (15.7)	0.008
Training for ≥3 years prior to pregnancy (hours/week)	1.6 (3.2)	20.3 (10.7)	14.3 (4.3)	<0.0001
Training during pregnancy (hours/week)	0.2 (1.2)	10.2 (12.7)	8.5 (7.4)	<0.0001
Gestational month training stopped	0.2 (1.2)	3.8 (3.9)	4.4 (3.8)	<0.0001
Years in highest division	0 (0)	8.7 (5.5)	8.4 (4.7)	<0.0001

Table 8 Cesarean sections, length of labor stages and perineal tears by exercise/impact group and associations between impact group in women with vaginal delivery.

	Non-athletic	Low impact	High impact	p-value+
Caesarean sections	**n=10**	**n=3**	**n=11**	
Elective (n)	1	1	1	0.51
Emergency (n)	9	2	10	
Vaginal delivery	**n=108**	**n=38**	**n=78**	
Length of labor stages				
1st stage of labor (min)+,#	603 (231-1069)	613 (331-1017)	600 (296-1386)	0.71
2nd stage of labor (min)+,##	57 (17-116)	56 (32-106)	65 (23-153)	0.22
Degree perineal tears				
0-2nd, n (%)	95 (88%)	29 (76.3%)	74 (94.9%)	0.01
3rd-4th, n (%)	13 (12%)	9 (23.7%)	4 (5.1%)	
Unadjusted OR (95%CI)	1.00	2.3 (0.9, 5.8)	0.4 (0.1, 1.3)	0.01
Adjusted OR (95%CI)*	1.00	3.6 (0.8, 17.1)	0.6 (0.1, 2.5)	0.01
Adjusted OR (95%CI)**	1.00	2.4 (0.5, 12.8)	0.4 (0.1, 1.7)	0.01

+Testing the null hypothesis that all three groups are equal. Chi-squared test was used in all cases except for length of 2nd stage labor where Kruskal-Wallis test was used. *Adjusted for maternal age, BMI and training frequency.

The study groups were not significantly different with regard to the number of emergency CS (p=0.51). No significant difference between groups was observed regarding the length of first and second stages of labor (p=0.71 and p=0.22 respectively).

The rates of 3rd and 4th degree perineal tears were significantly higher (23.7%) for low-impact athletes compared to the high-impact group (5.1%, p=0.01), but when each athletic group was compared to controls (12%), none of the group differences reached significance levels, (p=0.09 for low-impact and p=0.12 for high-impact athletes).

After adjusting for maternal age, BMI and training frequency, high-impact athletes still had lower risks of 3rd and 4th degree tears compared to controls and the risk observed for low-impact athletes was higher. However, for neither athletic group did this reach statistical significance when compared to controls. Further adjustment including birthweight did not influence the results. Penalized multiple logistic regression showed that the frequency of exercise before and during pregnancy, maternal age and BMI had each no significant association to any delivery outcomes.

5 Discussion

The results of the studies on which this thesis is based, show that in the early postpartum period a high proportion of primiparous women in a healthy Nordic-Caucasian population suffer some type of pelvic floor dysfunction. Anal incontinence and pain during intercourse had the highest prevalence among the symptoms experienced by the women, accompanied by bother related to such symptoms. Having more than one symptom was considerably more common among women delivering vaginally than for the women having had a cesarean delivery. From Study I onwards, an RCT (Study II) was conducted which confirmed the influence of PFMT for decreasing the rates of urinary incontinence and bladder related bother. The study thus confirmed what has been shown in other previous studies, namely that urinary symptoms are likely to respond to PFMT resulting in decreased symptoms. Training also increased both strength and endurance of the pelvic floor muscles and improved anal sphincter function, all measured as vaginal and anal pressure changes during muscular contraction. This could be a lasting effect with a difference still present at one year after the first childbirth for the women in the intervention group compared to the control group. Despite improved condition of the PFM the predominantly weak symptoms of AI (mostly flatulence) and pelvic organ prolapse were not influenced. This calls into question whether women with bothersome postpartum anal and POP symptoms should be targeted in a different way regarding the type of emphasis the treatment is built on. These symptoms possibly need higher training dosage and longer continuing training during this period when the connective tissue and muscles are healing and returning to its former condition.

We then sought, in a somewhat independent study to clarify better the outcomes of childbirth. This was done with regard to physical activity, investigating delivery outcomes and how these relate to the pelvic floor, of high- and low-impact elite athletes compared to more sedentary women. No differences of note were revealed regarding the rates of emergency CS or the occurrence of 3rd and 4th degree perineal tears. There was nonetheless a difference between the two athletic groups regarding serious perineal tears, where the high-impact group had more favorable outcome than the low-impact group in contrast to what might have been expected. The low-impact

group, however, was the smallest in the study as recruitment of these women was more difficult. Therefore, the results must be interpreted with caution, even if they are in themselves reassuring for women actively engaged in sports. No association was found between the frequency of training and delivery outcomes. As far as this study group knows, this has not been studied before and is therefore novel information. Sportswomen can expect an outcome from delivery which is comparable to other healthy women at least, and to not come out of a pregnancy with any excessive damage to their pelvic floor. They may even be better off with more resilience of the female body than other women.

5.1 Study I

Study I adds to the knowledge available at present on female PFD during an important period in a woman´s life, the time after a first childbirth. It is one of few reporting on symptoms from several domains in the same study. The results from this study concur with several other studies (Li, Xu, Zhang, & Zhu, 2019; Rortveit & Hannestad, 2014), showing that primiparous women have high rates of symptoms from the pelvic floor in the first months after childbirth.

In study I, both symptoms from the pelvic floor and perceived bother was reported. Bother is defined as trouble, nuisance, worry or something annoying (“Cambridge Dictionary,” n.d.). The feeling of bother is very personal, and most certainly different between individuals. It is likely to grasp both emotional as well as social and physical states. What bothers a woman in her postpartum period can be something that health care providers would not necessary pay attention to as such. The feeling of bother can therefore be considered to be unique for each person.

The most common PFD symptom in our study was that of AI, with over half (60%) of the women reporting problems that stem largely from anal sphincter function or dysfunction. This was not different between delivery modes which is in line with findings in the Cochrane review from 2010 (Nelson, Furner, Westercamp, & Farquhar, 2010). Controlling flatus appears to be difficult for about half of the women and when the rate of bother is considered, it is obvious that women are not unmoved by such symptoms and the social embarrassment they can cause. This is similar to the study of Cattani et al. (2019) who reported high rates of bother in adult women suffering AI and flatus incontinence (Cattani, Gillor, & Dietz, 2019).

Slightly fewer women, but still half of them, had urinary symptoms (overall prevalence 48%). This affected women delivering vaginally twice as much as those going through a CS. This applied to all forms of urinary incontinence: UI, SUI and UUI. This is supported by other studies (Li, Xu, Zhang, & Zhu, 2019; Rortveit & Hannestad, 2014). Surprisingly, fewer women proportionally (27%) were bothered by urinary symptoms than by the bowel symptoms. This is possibly linked to the embarrassment of not controlling flatus or bowel movements while losing urine can be managed in other ways. Perhaps more general knowledge of urinary symptoms may help along with the possibility of wearing protective pads. Even though many women rely on using pads, this should, however, not be normalized as done in many commercials (https://www.bbc.com/news/uk-49235784), (https://alwaysdiscreet.com/en-us/incontinence-products/ incontinence-pads#viewtype:gridview/ facets:/ category: incontinence- pads/page:1/ sortby:Featured-Sort/ products displayed :undefined/ cwidth:3/promotilesenabled:false/ pcwidth:1/cwidth:3/ pscroll:), and women should also be advised to seek help. Some urinary leakage may also be what women expect after childbirth and this could explain the relative low bother compared to the perceived bother of anal dysfunction. Coital incontinence was very uncommon (3%). In our study the reported urinary symptoms were also rather mild when measured by frequency of symptoms. Clinical experience supports this view, that women are in advance, more prepared for UI than other symptoms after childbirth. In the writer´s experience as a physical therapist primiparous women frequently seek help and advice postpartum and are surprised and worried about changes in their body functions which they did not expect after childbirth. This includes mainly the anal symptoms and changes related to sexual function which seem to come as a surprise after a first delivery. More emphasis on preparing women for the impact of pregnancy and childbirth, both in schools, in antepartum classes and during postpartum care is likely to be of benefit to prevent unease about symptoms that can in some ways be expected to be part of normal adaptation and restoration of the body after as dramatic an event as delivery of a child.

Pain during intercourse was also common complaint (66%) among the 55% of the participants who reported to be sexually active at 6-10 weeks after delivery. Of all women including those not sexually active, 48% reported to be quite bothered by sexual issues. Sexual function is complex and involves factors like quality of the relationship, depression, sleep deprivation and breastfeeding, all of which influence sexual function in the postpartum period (Chivers, Pittini, Grigoriadis, Villegas, & Ross, 2011; Lagaert et al.,

2017; Matthies et al., 2019). The high rate of sexually related bother might also be related to what women think is expected of them in terms of being sexually active, which can be in conflict with how they feel themselves. Partner expectations can also play a role regarding the matter. Studies have indicated that sexual dysfunction, especially sexual desire was related to partnership quality and depressive symptoms (Matthies et al., 2019; Wallwiener et al., 2017).

Breastfeeding is almost universal in Iceland during the first months postpartum (Thorsdottir, Thorisdottir, & Palsson, 2008) and this may have contributed to the high rate of dyspareunia seen in our study when dominating hormones affect the tissue of the lower genital tract resulting in vaginal dryness. It can also be considered likely that scar tissue so soon after childbirth can play a role in pain experience. In addition, the same women tend to report pain during intercourse both before and during pregnancy (Tennfjord et al., 2014).

POP was the symptom with the lowest prevalence (29%) and which caused women the least bother numerically (only 13% of all participants). In almost all cases women reported the mildest form (occasionally, < 1 x week) which explains the low level of bother. The higher rate of postpartum POP in women having VD is supported by several other studies (Chen et al., 2013; O'Boyle et al., 2005; Rortveit & Hannestad, 2014), but disputed by others (Colla et al., 2018). There is mounting evidence that symptoms of vaginal protrusion and heaviness in the postpartum period is related to heritable traits and therefore likely to become symptomatic during pregnancy (Durnea et al., 2017; Reimers et al., 2019; SZE, 2002; Urbankova et al., 2019). For a woman to experience heaviness, fatique or slight sensation of protrusion during the first months after childbirth is perhaps not surprising after carrying the baby and then giving birth to it.

Only few observational studies have focused on postpartum PFD symptoms from several domains simultaneously like our study did and sexual dysfunction is often left out. However, Durnea et al. (2017) used the same questionnaire as we did in a cohort study where early-pregnancy factors were taken into account and compared with the status of primiparas one year after the delivery (Durnea et al., 2017). They found that the adverse postpartum factors were mainly linked to existence of similar types of pre-pregnancy symptoms and to modifiable features like smoking, as well as to poorer social status and depression. Smoking and poorer social status tends in general to concur (Lund & Lund, 2005; Villalbí, Salvador, Cano-Serral, Rodríguez-Sanz,

& Borrell, 2007) and is thus not surprising. Some specific antepartum factors were also associated with postpartum symptoms. Urinary dysfunction was linked to a higher maternal BMI as well as to recurrent urinary tract infections and a need for induction of labor. Cesarean section was on the other hand protective for SUI and a higher BMI was linked to less reporting of sexual dysfunction (Durnea et al., 2017). Durnea et al. (2017) also found an association between pre-pregnancy vigorous exercises with postpartum POP symptoms and vaginal tightness (Durnea et al., 2017)

The lack of connections between PFD symptoms and maternal and delivery factors in Study I might be related to the absence of pre-pregnancy data, that could by the nature of the study not be collected. Colla et al. (2018) also studied sub-categories of PFD in the first three months postpartum and found no relations between mode of delivery and symptoms of PFD (Colla et al., 2018). As our intention for Study I was to create a platform for inviting symptomatic women to join our RCT in Study II we did not specifically study the pre-pregnancy state.

Urbankova et al. (2018) did also study four domains of symptoms. The rates of UI at 6 weeks postpartum, in part de-novo, were similar to our results, but AI-rates were much lower and sexual dysfunction was not reported so soon after birth. POP symptoms were only evaluated clinically at one year after childbirth which makes this study less comparable with our study (Urbankova et al., 2019).

Women taking part in Study I and who went through VD were more likely to have symptoms, including multiple symptoms, but most of the traditional delivery risk factors were not directly associated with the PFD symptoms. This may be because women in this study answered the questionnaire relatively soon after childbirth. When time passes it may become more evident how individual maternal and intrapartum factors play a role in creating more permanent symptoms, where these are present. We did not enquire about pre-delivery existence of these factors but others have done so and found as mentioned above, that pre-existing symptoms play a role (Durnea et al., 2017) as well as obstetric factors (vaginal more than cesarean delivery) do in the long term (Gyhagen et al., 2013a, 2013b).

In Study I there was, still a link between episiotomy and AI which is supported by the findings of Cescon et al. (2014) who described damage to the EAS innervation due to the episiotomy (Cescon et al., 2014). Higher birthweight was in our study only associated with increased risk of suffering UUI. Birthweight has though been related to UI in general in other studies

(Wesnes, Hannestad, & Rortveit, 2017). Likewise obesity in early pregnancy was associated with UI and had a marginal association with SUI and UUI among the women with VD as shown before (Wesnes et al., 2017; Wilson, Herbison, & Herbison, 1996). As obesity is a modifiable factor, education about lifestyle, including that of nutrition and physical activity should be a part of maternity care, but may indeed need to commence much earlier in life and be part of public health initiatives. Despite being both older and with higher BMIs than the VD women, no specific associations between symptoms of PFD and delivery factors were observed for women with CS. Birthweight is high in Iceland relative to many other countries (Kiserud et al., 2018; Löfling et al., 2016) and could have been a contributing factor to the obvious differences between VD and CS regarding UI and POP symptoms.

Most women will heal relatively rapidly after the first childbirth (Reimers et al., 2016; Staer-Jensen et al., 2015), but considering the mechanics of childbirth it is not a surprise that many will continue to suffer in the long run (Gartland et al., 2015; MacArthur et al., 2016; Viktrup et al., 2006). Education about postpartum symptoms should be a part of routine maternity care. Not to make women worried but rather to prepare them for the influence that childbirth can have, physically as well as emotionally. There is evidence to support PFMT for alleviating urinary symptoms and for improving POP symptoms in the general female population (Dumoulin et al., 2017, 2018;). Encouraging women to start strengthening their pelvic floor soon after delivery is also recommended (Woodley et al., 2020). Modifying some risk factors in a positive direction, like reducing obesity or smoking, improving bowel function and physical activity could be beneficial (Dumoulin et al., 2017; Milsom et al., 2017).

Our study supports the need for women to be given the opportunity to open a discussion with health care providers as regards symptoms that cause bother and where advice and help may be needed from specifically trained health providers who are near the women at this time of life. This will include obstetricians, midwives and physical therapists. The symptoms and the bother that they cause should not be disregarded.

5.2 Study II

Among primiparous women with UI after childbirth, we confirmed that regular PFMT noticeably reduced the symptoms and burden of UI immediately after the intervention. PFM strength and endurance were also improved. However, the PFMT did not influence the rate of anal incontinence and bowel-related

bother (Sigurdardottir et al., 2020). Results from the same study suggested in addition that the proportion of women with POP symptoms in the early postpartum period was not influenced by the PFMT intervention when assessed soon after treatment.

At the follow-up, one year after the first childbirth, the intervention and control groups showed similar rates of UI and AI, and also a similar prevalence of POP symptoms. There was improved strength and endurance of the PFM and anal sphincters in the intervention group for all measured parameters at one year postpartum.

The results regarding the influences of PFMT on UI in the postpartum period is a confirmation of outcomes from some previous studies (Dumoulin et al., 2004; Kim, Kim, & Oh, 2012; Morkved & Bo, 1997). The two most recent Cochrane reviews on the matter show similar outcomes even though the newer one from 2020 casts some doubt on the effectiveness of the postpartum PFMT intervention. The authors explain this change in conclusions with differences in handling of the data (Woodley et al., 2017, 2020).

Other studies have not shown an effect of PFMT in the postpartum period. In one study this may be related to the inclusion of women with verified levator ani muscle defects and the targeting of women with or without symptoms (Hilde, Staer-Jensen, Siafarikas, Ellstrom Engh, & Bo, 2013). Sleep et al. (1987) reported no effect on UI and fecal incontinence from an exercise regimen which was in the form of encouraging women early after childbirth to follow an exercise program without further support, and where the target group was also women with and without symptoms (Sleep & Grant, 1987).

The results from Dumoulin et al. (2004) are on the other hand impressive, with a 70% cure rate in the intervention groups. Their study excluded women with pre-pregnancy UI and began later in the post-natal period than ours. The control group women were also asked not to exercise their PFM during the study time, but received relaxing massage as a substitute for the increased attention the intervention group women got (Dumoulin et al., 2004).

Participation in a study is an intervention in itself, even for the control group. Our study as most other began with evaluation and verification of PFM function and therefore added an element of encouraging and teaching of correct contraction methods for the PFM. The control group women in our study were not discouraged from doing PFM exercises, however, the

exercise diaries and answers from a questionnaire showed poor adherence to any regular practice for the participants in general. It is a reason for concern that a group of primiparous women with UI soon after childbirth still showed symptoms one year later, whether or not they received physical therapy for their symptoms or not. In our case 77% of our participants were still symptomatic at that time, even though the rate of UI was less at the end of treatment among intervention group women. Inclusion of women with pre-existing symptoms might explain this outcome in part. It is likewise uncertain whether adherence to the exercises was sufficient in the intervention group. Many women lost their diary or did not record home exercises during the intervention period and relatively few continued to exercise after the intervention. Nonetheless they were encouraged throughout the intervention period by their physical therapist to do daily exercises. That this seemed for the majority of the women not to happen is understandable in the busy time of caring for a child which is likely to dominate during daytime. The higher prevalence of UI at one year postpartum might also have been related to gradual increase in physical activity among the women. This is likely to happen as time passes from the childbirth, revealing concealed pelvic floor weakness.It is still worrying that these primiparous and generally well-educated women in a high-resource country do not do more to optimize their own health in the year after childbirth.

The results of no effect of PFMT on AI are in line with several other RCTs as shown in the most recent Cochrane review (Woodley et al., 2020). However, there are at least two RCTs showing positive changes regarding AI in postpartum women. The study of Johannessen et al. (2016), covering six months and beginning on average one year postpartum, where women of different parity were included, showed positive results of the training program on anal symptoms. The study involved individual 4-6 appointments with a physical therapist over this half-year period with encouragement to perform PFMT. The same exercise protocol was used as in our study (Johannessen et al., 2017). The study of Glazener et al. (2001) was somewhat different in practice. It involved home visits of a nurse in the 3^{rd} , 6^{th} and 9^{th} months postpartum who taught and reinforced women to perform the PFM exercises over this period. The aim was to have the women performing 80-100 slow and fast PFM contractions daily (Glazener et al., 2001). Whether the key to success was the duration of the intervention, the later beginning after childbirth or the fact that these studies were sufficiently powered is worth exploring. Our study showed significant improvements in PFM- and anal sphincter strength over the study period and therefore had the potential to

diminish AI. It is possible that improvement regarding AI needs longer time to happen. The overall percentage of AI in Study II was 70% at recruitment and 61% one year postpartum. Even though AI consisted in our sample of mostly mildly symptomatic women, the AI was still reported to be bothersome by the women. We agree with the authors of the Cochrane review and others that more research is warranted and with longer follow-up of treatment for women suffering from at least the more severe forms of AI in their postnatal period (Woodley et al., 2020).

The prevalence of POP symptoms diminished steadily during the first year postpartum for the participants as one whole group. However, when analyzing the numbers, the intervention group went from 42.5% to 22.2% at the end of the treatment and from endpoint to follow-up the rate went down to 10.5%. The control group numbers changed differently, from 36.6% down to 7.9% at endpoint but increased again and were 14.3% at follow-up. The total change in prevalence over the year was greater for the intervention group (32% vs. 22% for controls), but the lack of statistical significance does indicate that the differences could at best have been marginal. For this variable our study lacked power with a risk of type II error. The secondary analysis of POP symptoms was based on a low rate of symptoms, 29% of all participants, in all 32 women (17 intervention vs. 15 controls) who had symptoms at recruitment. The changes experienced by women in the intervention group may nonetheless be considered as being in line with the steady increase in strength and endurance of the PFM.

Few studies have looked at POP symptoms and PFMT in the postpartum period. The results from Bo et al. (2015) with much larger groups of participants concur with our findings (Bo et al., 2015b), but Yang et al. (2017) had more positive results (Yang et al., 2017). Both studies were conducted in the early postpartum period as our study. There is a need for larger RCTs on women showing symptoms of POP in the postpartum period and the effects of PFMT or other possible conservative methods.

The first year postpartum is a challenging time for women. The attention swifts dramatically to the newborn and women are often deprived of sleep due to breastfeeding and the sleep patterns of the baby. Physical, emotional and hormonal changes also matter in the overall picture. The question remains whether or not it is feasible to initiate a PFMT exercise program soon after childbirth and if so when such a program should commence. Our study which included only women with symptoms of PFD showed positive results for urinary symptoms, indicating that the healthcare system should be

focused towards the needs of symptomatic individuals. Women without symptoms in the postpartum period could possibly rely on basic education about PFM exercises.

One way to look closer at the pelvic floor condition after childbirth is to compare it to a sports injury. The tissue of the pelvic floor can be looked at as "injured", both in terms of stretching of the connective tissues like fascias and ligaments, and there is also tearing of muscle fibers, strains, tears and contusion in the bony pelvis attachments. Damage to the motor innervation and over-stretching of the pudendal nerve and its branches occurs (Corcos, 2015). This all weakens the pelvic floor as a functional unit, even if by one year after childbirth most women may have gone back to normal. But this does not happen to them all and finding, supporting and treating those who do not is necessary, both as a health and a research issue. Then the question becomes: When and how is wise to begin pelvic floor muscle training?

According to methods in sports medicine the first treatment to injury is RICE: rest, ice (applying cool packs), compression and elevation, following early careful mobilization within the limits of pain (Gartner, 2014). Rest and cool packs in the immediate period after childbirth is easy to recommend, but it may be less easy to follow the advice. Compression and elevation is possibly an applicable approach to the pelvis. It is, however, not known if recommending rest in positions with minimal gravitational influences to lessen edema in the pelvis (like knee-to-chest position) is of any value.

In sports medicine rehabilitation after the acute stage should commence with muscle contractions without undue pain, followed by range of motion exercises with limited loads to enhance tissue healing and progress to maximal isometric contractions. From there, careful concentric contractions can be applied with resistance, gradually improving endurance and move to more loads in order to improve strength and power (Brukner & Khan, 2014). It is of interest to study if principles of treating pelvic floor tissue injury from day one after childbirth in a way similar to sports injuries and before starting an active training program, would add to healing and improvement for the PFM and PFD symptoms in the postpartum period.

Could delaying PFMT be another method to improve the results regarding dysfunctional symptoms from the pelvic floor? Women might be in a better position to focus on their own health if they commended exercise programs later. Could the key to the impressive study results of Dumoulin et al (2004) have been the timing of the intervention, which began late in the postpartum

period? (Dumoulin et al., 2004) Conversely, it is known that muscle function improves more if a demand is placed upon the muscles, which should encourage early start of exercises (Garber et al., 2011). Women are also likely to become more active when time passes from the childbirth and therefore it must be considered prudent that they practice PFMT as well as engaging in physical activity from early on. Neels et al (2017) found that immediately after childbirth, bodily functions like micturition, defecation and activities of daily living were more painful for the pelvic floor than PFM contractions. Similarly at 9 weeks postpartum, despite that some women suffered pain during sexual intercourse and defecation, they did not experience pain during PFM contractions (Neels, De Wachter, Wyndaele, Wyndaele, & Vermandel, 2017). In this RCT principles of strength training were followed and no women reported pain or other adverse events during PFM contractions over the intervention period.

Is it therefore wise to recommend careful muscle activation to enhance muscle memory and relaxation to begin with before starting a strengthening program for the PFM? What is the best way to encourage women to start and continue to do PFM exercises in the postpartum period? It is imperative to look at this question both from the economic point of view and also regarding how practical this can be for the woman in light of time and what appeals to her. This may be in the form of exercise classes, personal contact with a health care provider or with apps to name a few options.

5.3 Study III

When Study III was conducted no studies had been identified by the study team addressing the delivery outcomes among elite athletes. A review from 2016 on the influences of physical activity and/or regular exercises among women, showed a trend of no different or more favourable childbirth outcomes in association with physical activity, exercises or PFMT before or during pregnancy (Bo et al., 2016). The article suggested a moderate evidence-level regarding no negative influence of exercise on the rate of induction of labor, episiotomy or the use of epidural anesthesia. The review also documented moderate evidence that physical activity during pregnancy did not lengthen the duration of labor, and some findings suggested that the duration of labor might be shorter in women who are physically active. Regarding the rate of emergency CS the authors found inconsistent evidence about the influences of exercise during pregnancy and no studies were found on the influence of exercise on levator ani muscle defects or anal sphincter tears (Bo et al., 2016).

The results from Study III indicate that elite athletes do not experience more difficult childbirth when comparing them with more sedentary women. The exception is the high rate of serious perineal tears among low-impact athletes in comparison to the high-impact group. This calls for further studies on low-impact athletes, which was the smallest group in the study and therefore the results cannot be considered precise. Among low-impact sports there are some interesting fields when considering the impact on the pelvic floor such as weight-lifting and horseback riding. Weight-lifters must engage with a high IAP when lifting weights even though there are not high ground-reaction forces present. Their PFM can react with contractions or the athlete can bear down (Bø & Nygaard, 2020). Horseback riding is another sport unlike most others where the jockey must move in harmony with the horse, possibly influencing the condition of the pelvic floor as strained during jumping and landing impact even though the legs of the athlete are not. Prospective studies are needed to add to our knowledge about the association of different sports with respect to childbirth.

What is beneficial and what works against the elite athlete in relation to childbirth? Elite athletes need to be stronger and in better physical condition than the average person, even if the average person is engaging in regular exercise. However, we cannot know if the female elite athlete has good enough coordination when activating her trunk muscles, among which are the PFM. Several studies have confirmed that competitive female athletes do not have stronger PFM than other women (Borin et al., 2013; Ludviksdottir et al., 2018) and regular exercise is associated with wider LH which can be beneficial during labor (Bo et al., 2015a). Nonetheless, nulliparous athletes have been found to have larger (more volume) PFM than controls (Kruger et al., 2007, 2005), which can reflect that female athletes have a larger muscle mass in general than the average woman. Elite athletes might also benefit from stronger abdominal muscles during the active phase of the second stage of labor (Bo et al., 2016). According to the results of our study, delivery outcomes of female elite athlete seem to be in line with that of other women but the high rate of serious perineal tears among the low-impact athletes needs more scrutiny.

We divided our athletes according to the type of impact of their sport. Today most athletes take part in additional training beside their own sport to maximize their condition. For the runner this might be training with weights and for the weight-lifter this could additionally be swimming or running to name a few (Beattie, Kenny, Lyons, & Carson, 2014; Berryman, Mujika, & Bosquet, 2019). The approach used in Study III can therefore be questioned

as measuring the influences of the additional training can be complicated. We did, however, analyse if the frequency of training itself had any relation with delivery outcomes and found no connection.

Given the above data, the condition of elite athletes does not seem to be unfavourable during childbirth.

5.4 Strengths and limitations

All the studies had the strength of being done in a relatively uniform and healthy Nordic-Caucasian population where healthcare is largely state-run, accessible and affordable. At the same time this may also be perceived as a lack of diversity, both in terms of possible ethnic and socioeconomic differences. It is though likely that common problems associated with childbirth are the same for all women, although to a different degree depending on the circumstances. The high birthweight and the general wish among women in this population to give birth normally was, however, also an advantage that might have been expected to shed light on some aspects of pelvic floor dysfunction.

The strengths of Study I include the prospective design and the large sample size with a high response rate. The questionnaire included four different domains of symptoms from the pelvic floor which gave an overview of each woman´s condition with regard to her pelvic floor. The lack of information on pre-pregnancy PFD can be considered as weakness when searching for risk factors for the primary outcomes but the prevalence of symptoms and bother in the immediate postpartum period stands for itself. Regarding the generalizability of the results from Study I, it is unknown if the staff midwives at the maternity ward were more successful in recruiting women after uncomplicated or even after more difficult deliveries. Women experiencing the latter could possibly be more likely to be interested in the aftermath of the birth and therefore more positive towards participating in such a study. The reverse could also be the case. Thus, we cannot be certain if the sample represented the primiparous population or if a selection bias existed.

In Study II the randomized and blinded design and the high adherence to the intervention sessions is a considerable strength. The study period extended and followed the women for one year after the childbirth thus shedding light on the evolution after the intervention itself. The physical

therapists responsible for the intervention were also experienced in the field of women´s health with knowledge of PFMT and the use of biofeedback devices, and familiar with general encouragement and education towards the participants. The study was sufficiently powered to detect changes in UI, but not to identify significant changes regarding AI or POP symptoms.

The Icelandic translation of the Australian Pelvic Floor Questionnaire used in Study I and II was not validated in advance, but the questions were mainly direct translation of simple questions and should thus have had a required representative strength. We believe that there is not much of cultural differences that could have affected the understanding of each individual question. The translation process and pre-testing was as well done and in line with rigorous methodology (Beaton et al., 2000). The questionnaire has been translated and validated in several languages and is known to have good psychometric qualities (Argirović et al., 2014; Baessler, Mowat, & Maher, 2019; Baessler et al., 2010; Hou & Hou, 2020; Sarıibrahim Astepe & Köleli, 2019).

The sample size in Study III was relatively large and the response rate was high as in the other studies. The retrospective design in Study III is a limitation and thus the possibility of a recall bias existed. Despite that, we were able to recruit many of the most successful female athletes in Iceland; women who must have trained meticulously. Within a reasonable timeframe, we did not succeed in recruiting enough low-impact athletes which was a drawback.

For all studies, the use of information from a national medical birth registry is a strength. All participants in the studies for this thesis were of Caucasian ethnicity which is both a methodological strength and a limitation.

5.5 Future perspectives

As described in Study I dysfunctional symptoms from the pelvic floor are highly prevalent among primiparous women in the immediate weeks after childbirth. Although many studies have focused on the relation between genetic, maternal, delivery and external factors, this may perhaps never be fully understood. Further studies are warranted to add understanding as to why some women suffer more than others from pre- and postpartum PFD. Based on the studies presented in this thesis several ideas emerged regarding future research. It is and probably will be a continuous debate on if, how and when pelvic rehabilitation should be implemented after childbirth. Guidelines are also not clear in Iceland regarding this in maternity care where

physical therapists can play a bigger role in cooperation with other healthcare providers. It is of interest to study if different approaches, in line with the care provided to athletes after sports injury, would make a difference. Beginning early with careful treatment in line with the RICE approach and then progress with increasing demands on the muscular component of the pelvic floor. A comparison of different timing of intervention is also needed.

Further RCTs on the influences of PFMT or other conservative treatment for AI and POP symptoms in the postpartum period are necessary to narrow the gap in our knowledge regarding ways to help women with their symptoms and bother.

How can women be encouraged to be active in doing PFM exercises? Most of the available evidence points towards the benefit of regular PFM exercises when women have symptoms related to weakness of PFM. However, according to Study II, adherence to the exercise regimen was not confirmed by many of the participants. Methods on how postpartum PFMT could have the best results should be studied with cost-effectiveness in mind along with evaluating better the nature of support from different categories of healthcare providers. Modern technology has much to offer in this field. Evidence on physical activity and training points towards favorable outcomes when it comes to the delivery process, both among physically active women and professional athletes.

6 Conclusions

In this thesis I have endeavored to give a new view on pelvic floor dysfunction and the discomfort, bother and problems that are connected to individual PFD symptoms in healthy primiparous women. This was done by assessment of the symptoms 6-10 weeks postpartum and the comparison between women going through vaginal and cesarean delivery. In this population where birthweight is high, women delivering vaginally are more likely than women going through cesarean section to suffer from urinary and prolapse symptoms but not anal symptoms or pain during intercourse. This reflects on actual symptoms and bother at this point in time after childbirth and should be considered of clinical value.

In a subgroup of symptomatic women who contributed to the study of PFD prevalence, supervised postpartum PFMT decreased the number of women who were urinary incontinent by the end of treatment, but continence rates were not fully sustained by 12 months postpartum. Anal incontinence rates were not altered due to the intervention nor was the rate of pelvic organ prolapse symptoms. However, the number of women with POP symptoms in this subgroup decreased steadily during the first year postpartum, indicating good ability of recovery after the first childbirth.

When analysing delivery outcomes in relation to physical activity before and during the first pregnancy in another subgroup of women who were either not involved in sports or participated at elite level, we did not find an association between being in competitive sports at elite level and higher rates of emergency cesarean section, prolonged second stage of labor or 3^{rd}-4^{th} degree perineal tears suggesting no adverse link between sporting activities at a professional level and childbirth outcomes.

We suggest that due to their insight and knowledge regarding physiology and muscle function, physical therapists should be active in maternity care to educate women and encourage PFMT in the pre- and postpartum periods.

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Original publications

Article I

Pelvic floor dysfunction and pelvic outlet bother in primiparous women 6-10 weeks postpartum - comparison between vaginal and cesarean delivery

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Contribution to Authorship
Sigurdardottir, Steingrimsdottir, Geirsson and Bø contributed to the design, execution, analysis and interpretation of the study, while Halldorsson and Aspelund contributed to the design and analysis of the material. All authors have contributed to the writing of the manuscript.

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Abstract

Objective

To study the prevalence of pelvic floor dysfunction and related bother in primiparous women 6-10 weeks postpartum, comparing vaginal and cesarean delivery.

Study design

A cross-sectional study on 721 mothers with singleton births in the capital area of Reykjavik, Iceland, 2015 to 2017, using an electronic questionnaire. Information on urinary- and anal incontinence, pelvic organ prolapse, sexual dysfunction with related bother was collected. Main outcome measures were prevalence of postpartum pelvic floor dysfunction and related bother.

Results

The prevalence of urinary and anal incontinence was 48% and 60%, respectively, with 27% and 56% of the total sample experiencing this as bothersome. Pelvic organ prolapse was noted by 29%, with less than half of these women finding this bothersome. Of sexually active women, 66% reported coital pain. Of all the women 48% considered sexual issues bothersome. Urinary incontinence and pelvic organ prolapse was more prevalent in women who delivered vaginally compared to cesarean section, but no differences were observed for anal incontinence and coital pain between groups. Compared to normal weight women, being obese was a predictor for urinary incontinence among those delivering vaginally (OR 1.94; 95%CI 1.20-3.14). Birthweight above the 50th percentile was predictive for urgency incontinence after vaginal delivery (OR 1.53; 95%CI; 1.05-2.21). Use of episiotomy predicted anal incontinence (OR 2.19; 95%CI; 1.30-3.67). No associations between maternal and delivery characteristics were found for pelvic floor dysfunction among women undergoing cesarean section.

Conclusions

Bothersome pelvic floor dysfunction symptoms are prevalent among first-time mothers in the immediate postpartum period.

Key words

Anal incontinence, childbirth, coital pain, pelvic organ prolapse, primiparas, urinary incontinence.

Brief summary

Pelvic floor dysfunction is highly prevalent 6-10 weeks after first childbirth. Women experience most bother from anal symptoms and sexual issues.

Abbreviations

AI, anal incontinence

BMI, body mass index

CI, confidence interval

OR, odds ratio

PFD, pelvic floor dysfunction

PFM, pelvic floor muscles

POP, pelvic organ prolapse

SD, standard deviation

SUI, stress urinary incontinence

UI, urinary incontinence

UUI, urgency urinary incontinence

Introduction

Childbirth can be a major cause of pelvic floor dysfunction (PFD) among women of childbearing age [1,2], but how much mode of delivery matters in the development of symptoms is less studied [3]. In a previous study, we found that women going through either normal or instrumental vaginal birth were measured with less pelvic floor muscle (PFM) strength and endurance than women undergoing cesarean section 6 weeks postpartum [4], a finding confirmed by other studies [5].

Women suffering from urinary incontinence (UI), anal incontinence (AI) and pelvic organ prolapse (POP) have also a higher risk for developing sexual dysfunction [6], but in the early postpartum period other factors such as hormonal status that has not yet returned to the pre-pregnancy stage must be considered [7]. Symptoms of PFD are largely related to pelvic floor injuries and some obstetric/delivery factors, which may worsen symptoms [3,8]. During pregnancy and even after a cesarean section, women often experience symptoms of PFD, showing that predisposing pre-pregnancy maternal characteristics, genetic or hormonal factors play an additional and as yet undefined role [9]. Symptoms of AI, including uncontrolled flatus, are distressing for women [10], and have been primarily related to obstetric anal sphincter tears [11]. Women presenting with postpartum PFD symptoms are also likely to suffer from depression and anxiety [12]. Physical and psychological dysfunction connected to PFD can therefore negatively influence the experience of new motherhood.

In the clinical setting it is thus important to have information about the prevalence of postpartum PFD and establish the extent of problems when women seek advice after childbirth. Our primary aim was to study the prevalence of PFD and related bother in a primiparous population with high birthweight [13], 6-10 weeks after delivery and compare

vaginal delivery and cesarean section in this respect. We sought as well to describe delivery-related characteristics associated with PFD.

Material and Methods

Study design

This was a cross-sectional study of 721 Caucasian primiparous mothers with singleton pregnancy. Information on maternal characteristics and delivery outcomes extracted through hospital records and information on symptoms of pelvic floor dysfunction were collected through a self-administered electronic questionnaire 6-10 weeks postpartum. Inclusion criteria were ≥18 years of age and understanding Icelandic. Exclusion criteria were stillbirth, multiple birth, delivery <28 gestational weeks or an unwell newborn, and pre-existing diseases/conditions likely to predispose to PFD. This comprised previous bladder/bowel diseases, neurological, psychiatric and cognitive disabilities that could influence women´s ability to answer the questionnaire.

Ethical approval was obtained from the Icelandic National Bioethics Committee (Ref: VSN-13-189), the Data Protection Authority (Ref: 2014030475TS/--) and Landspitali University Hospital (Ref: 16. OB/ei).

Recruitment and participants

Women were recruited at Landspitali University Hospital, Reykjavik, between April 2015 to March 2017. Before being discharged from the maternity ward staff midwives asked eligable mothers to take part in the questionnaire study and give their e-mail for further information and formal consent. An e-mail including a weblink to the questionnaire and detailed information about the study was sent to the participants six weeks postpartum and the link was active for four weeks. Weekly reminder e-mails were sent up to three times. Answering the questionnaire was taken to indicate informed consent. Of the 858 women who agreed to participate, 721 (84%) returned the questionnaires.

Outcome assessment

An Icelandic translation of the Australian Pelvic Floor Questionnaire was used [14]. This had been translated and pre-tested [15] with authorial approval. The questionnaire has four domains: bladder-, bowel- and prolapse symptoms and sexual function. Urinary, flatus and fecal (liquid or solid) incontinence are defined by frequency of leakage. Other questions include nocturnal symptoms, pain and bladder emptying problems, constipation, prolapse described as vaginal protrusion or heaviness, the need for manual pressure to void or empty bowels, coital pain and incontinence. Answering "never" was considered equal to no symptoms in all domains. Questions used were for UI "Does urine leak when you rush or hurry to the toilet? Do you not make it in time?" and "Do you leak with coughing, sneezing, laughing or exercising?" This also distinguished between urgency (UUI) and stress (SUI) urinary incontinence. For AI the questions were: "When you get wind or flatus, can you control it or does wind leak?", "Do you leak watery stool when you don´t mean to?" and "Do you leak normal stool when you don´t mean to?". POP was investigated by "Do you have a sensation of tissue protrusion or a lump or bulging in your vagina?" and "Do you experience vaginal pressure or heaviness or a dragging sensation?" Regarding sexual function the questions: "Are you sexually active?", „Do you experience pain with sexual intercourse?" and "Do you leak urine during sexual intercourse?" were used. Answers of "occasionally, frequently and daily" were considered as indicating urinary and anal incontinence, POP and/or coital pain. Bother in all domains was considered absent when the answer was "not at all" or "not applicable, I do not have a problem". Answers of "slightly, moderately, greatly" were considered as bother. According to this approach, data was analyzed as from two categories, 0= no symptoms or no bother and 1=signs of symptoms and/or of bother.

Information on maternal characteristics and birth outcomes

Maternal charcteristics and birth outcomes were extracted from the Icelandic Medical Birth Register. This included maternal age (years), body mass index (BMI) as kg/m^2 at the first antenatal visit, delivery mode, duration of 1st and 2nd labor stages (registered in minutes, converted to hours), 3rd and 4th degree perineal tears, episiotomy, anesthesia/epidural, fetal presentation, birthweight (g), birth length and newborn head circumference (cm).

Statistical analysis

When describing continuous normally distributed variables, the mean and standard deviation (SD) was used while precentages were applied to describe dichotomous outcomes. Stages of labor which are skewed continuous variables were described with median and 10th- 90th percentiles. The chi-squared test was used for formal differences between groups with regard to dichotomous outcomes, while the t-test was used for continuous outcomes. Prevalences of self-reported PFD and related bother were described in terms of proportions (%) and frequencies (n) for all women and stratified by mode of delivery (vaginal delivery and cesarean section).

Associations between maternal characteristics and other obstetric outcomes with pelvic floor dysfunction stratified by vaginal delivery and cesarean section, were then examined using multiple binary logistic regression. Maternal characteristics and birth outcomes included maternal age, BMI (<25 kg/m^2 used as a reference group compared to overweight, ≤30 kg/m^2 and obesity, >30 kg/m^2), birthweight (≤50th (≤3600 g) vs. >50th percentile (>3600 g), length of 2nd stage of labor in hours (with ≤1 hour as a reference), presence or absence of 3rd and 4th degree perineal tears, episiotomy and instrumental delivery (vacuum and forceps extractions). As a result of co-linearity between birthweight and newborn head circumference (r=0.8,

p<0.001) only birthweight was used for analysis. For these characteristics missing values were generally low (1-4%) and complete case analyses were performed.

We used SPSS, version 26 (IBM, Armonk, NY, USA) for all statistical analyses. Significance levels were set to $p < 0.05$.

Results

Participant characteristics

Table 1 shows characteristics of the women and delivery outcomes. Eighty-three percent (n=601) of the women delivered vaginally and 17% (n=120) had cesarean section. Mean age was 27 years (range 18-47). Women with cesarean section were older than women giving birth vaginally, 29 years (SD 5.7) vs. 27 (SD 4.6) ($p<0.001$) and with a higher BMI, 28 (SD 6.2) vs. 25 (SD 5.4) ($p<0.001$). Only eight of 98 women delivering with emergency cesarean section reached the 2nd labor stage. Birthweight was significantly higher for women giving birth vaginally, 3575 g (SD 511) vs. 3559 g (SD 748) for the cesarean group ($p<0.001$).

Prevelance of PFD

Table 2 shows the frequency of PFD symptoms. Women reporting no symptoms constituted 12%. The prevalence of any UI was 48% (n=708) with 27% of all participants finding urinary symptoms bothersome. AI was present in 60% (n=430), with 396 of these women suffering only flatus incontinence. Of all study participants 56% reported anal symptoms as bothersome. The prevalence of AI was not different between those with or without 3rd and 4th degree perineal tears ($p=0.3$). POP symptoms were reported by 29% of the women (n=205) and 13% of all participants considered this bothersome.

Sexually active women at 6-10 weeks were 55% (n=386). Of them, 3% (n=10) experienced coital urinary incontinence and 66% (n=254) pain during intercourse. Of all participants, including the women who were not sexually active, 48% found sexual issues bothersome. Urinary and prolapse symptoms were more prevalent in women who delivered vaginally, but the AI prevalence was not different. More women in the cesarean section group were sexually active, but coital pain was not different between delivery routes.

No or one symptoms were more common among women having a cesarean section (n=77, 64% vs. 245 of women having vaginal delivery (41%)), while two, three and four symptoms prevailed to a greater degree among those delivering vaginally (n=356 (59%) vs. 43 (38%) of cesarean section women, $p<0.001$).

Table 3 shows the association between maternal characteristics and birth outcomes with PFD among women who delivered vaginally. Compared to women of normal weight (BMI<25kg/m^2) being obese at first antenatal visit was significantly associated with postpartum UI. Birthweight >50^{th} percentile was significantly associated with UUI. Undergoing episiotomy during vaginal delivery was significantly linked to AI. No association was seen for symptoms of SUI, coital pain or POP and delivery factors in women with vaginal delivery. No association was observed between maternal characteristics and birth outcomes with PFD among women giving birth via cesarean section (Table 4).

Discussion

Main findings

High rates of symptoms from urinary (48%) and anal incontinence (60%), POP (29%) and coital pain (66%) were reported among first-time mothers 6-10 weeks after delivery in this study. All forms of UI, POP and related bother were more prevalent after vaginal delivery compared with cesarean section, while for AI and coital pain there was no difference. After vaginal delivery multiple symptoms were more likely. After evaluating prevalence for the vaginal delivery and cesarean section groups we examined associations between delivery factors and each symptom of PFD with logistic regression. For women with vaginal delivery there was an association between episiotomy and AI, and between higher birthweight and UUI. Obesity in early pregnancy was significantly associated with UI and had borderline association with SUI and UUI, and this all applied to women with vaginal delivery.

Interpretation

The findings concur with previous studies showing increased prevalences of UI, SUI and UUI in the early postpartum period in primiparous women after vaginal delivery compared to cesarean section [16]. In a systematic review UI was reported to be twice as high at three months postpartum for women delivering vaginally, while results for AI were inconclusive [16].

We found an association between obesity at first antenatal visit and UI, - a finding which was also borderline significant for UUI and SUI. Reflecting the population prevalence, a high number of the participating women were obese (20%), with BMIs from 30 to 50 kg/m^2. Obesity is modifiable and this emphasizes the need for education about lifestyle before and during pregnancy, such as providing incentives and advice for healthy eating and physical

activity. The association between higher birthweight and having urinary symptoms was only present for UUI. Higher birthweight and increased head neonatal circumference has though been considered in some studies as a risk factor for urinary symptoms [3]. In this study, women delivering vaginally had significantly heavier babies than the cesarean group.

The prevalence of AI was high, with 60% of women reporting symptoms and 56% of all participants being bothered by this. Even though this mostly concerned flatulence, women are not indifferent to this, since anal symptoms probably cause more social embarrassment than UI [10,17]. There were, however, no differences in the AI prevalence between delivery modes, as has been noted before [18]. We could not associate anal sphincter tears with increased rates of AI, even though 8% of the women suffered such damage to their pelvic outlet. This may partly be due to increased awareness and better immediate repair practices for serious obstetric sphincter ruptures during the last two decades [19]. Over time women with pelvic floor injuries may though have been more vulnerable to adverse symptoms, as described by DeLancey et al [20]. Continuity of bothersome symptoms from a first pregnancy and into later life-stages and further child-bearing requires better exploration.

Episiotomy increased the odds of AI twofold. This is supported by the results of Cescon et al who showed damage to EAS innervation at the site of the episiotomy at 6-8 weeks postpartum, a phenomenon not present in women who delivered without episiotomy or by cesarean section [21]. This might explain the association between episiotomy and AI found at a similar time in this study, when the pelvic floor tissues are still at a recovery stage.

Bother from prolapse was the least reported bother in our study, suggesting that the symptoms were mostly mild. Although three times more common among women with

vaginal delivery, no single factor was identified as a potential risk for POP. The strongest risk for clinically objective POP 6-10 weeks postpartum has previously been related to the pre-labor pelvic floor state rather than delivery variables [22]. After a first delivery women seem to have a good ability to recover from POP symptoms [9].

Bother from sexual dysfunction was, however, high. Of all the women, including those who reported not to be sexually active, 48% considered sexual issues as bothersome. This concurs with Lipschuetz et al [17] who described high rates of bother from dyspareunia one year after first childbirth, underlining the need for health-care providers to pay attention to sexual function during the puerperium. Postpartum sexual issues merit further robust research, as factors apart from the childbirth can influence this, such as partnership quality, sleep deprivation, depression and breastfeeding [23].

Sexual dysfunction soon after childbirth seems to have a predictive value for continuing symptoms [7]. Similar to Tennfjord et al [24], we found no difference in the prevalence of coital pain between women with vaginal delivery or cesarean section, but a link between dyspareunia and breastfeeding is known [7,24]. This may have been the case in our study as breastfeeding is almost universal in Iceland during the first months postpartum [25]. A link between increased maternal age and a higher risk for PFD was not found. The study women were relatively young (mean age 27 years), however, the cesarean section group was both older and with higher BMIs than the vaginal delivery women.

During the postpartum period many women may need a tangible opportunity to speak to health care providers about their concerns regarding PFD. The high response rate in this study indicates that women are ready to open a conversation which could lead to useful

advice for appropriate treatment options soon after childbirth. Studies have shown that postpartum pelvic floor muscle training will reduce UI [27,28], even if less evidence is available regarding postpartum treatment of POP and AI symptoms [28,29]. Healing and restitution will take time [30], and bothersome symptoms must be expected, not least in a population where breastfeeding is almost universal [24]. Knowledge about postpartum bother should be part of general education on childbearing.

Strengths and limitations

Strengths of this study are a large sample size, a high response rate, use of data from a national medical birth register and the covering of four PFD domains, including sexual dysfunction. A lack of formal validation of the Icelandic translation of the questionnaire was a limitation, but it was translated and pretested according to rigorous methodology. We also lacked pre-birth information, and longer follow-up of the participants would have been desirable. Information is needed as to the extent to which symptoms and bother pre-exist or are persistent phenomena.

Conclusions

In a population where birthweight is high, PFD and bother from symptoms were common among Caucasian primiparas 6-10 weeks postpartum, reflecting actual symptoms and bother at this point in time after childbirth among first-time mothers. Women delivering vaginally are more likely than women going through cesarean section to suffer from urinary and prolapse symptoms, but not from anal symptoms or coital pain.

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Details of Ethics Approval

Ethical approval was obtained from Icelandic National Bioethics Committee (Ref: VSN-13-189), and Data Protection Authority granted permission as well (Ref: 2014030475TS/--). The study was conducted in accordance with the Helsinki Declaration on human experimentation.

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Table 1. Characteristics of study participants[1]. Presented as mean with SD or numbers (n) and %.

	All participants (n=721)	*Vaginal delivery (n=601)*	*Cesarean delivery (n=120)*	*P- value[2]*
Age at first antenatal visit (years)	27 (4.8)	27 (4.6)	29 (5.7)	0.002
BMI at first antenatal visit (kg/m^2)	26 (5.6)	25 (5.4)	28 (6.2)	0.007
BMI <25	57%	61%	39%	
BMI 25-≤30	23%	22%	28%	
BMI>30	20%	17%	33%	
Gestational length (weeks)	39.5 (1.6)	39.5 (1.4)	39.2 (2.2)	<0.001
New-born variables				
Birthweight (g)	3572 (557)	3575 (511)	3559 (748)	<0.001
Delivery variables				
Mode of delivery (%)				
Vaginal delivery (n=601)	***83%***			
Spontaneous vaginal delivery	67%			
Instrumental; vacuum and forceps	19%			
3rd and 4th degree perineal tears	8%			
Episiotomy	17%			
Epidural anesthesia	66%			
Length of 1st stage (hours)[3]	10 (3.75-18.25)			
Length of 2nd stage (hours)[3]	1.15 (0.38-3.39)			
Cesarean delivery (n=120)	***17%***			
Emergency[4]	14%			
Elective	3%			

[1] Independent samples t-test for continuous variables. [2] P-value for differences between vaginal and caesarean delivery. [3] Median with 10th-90th percentile. [4] 8% of women going through emergency cesarean delivery reached 2nd stage of labor, one of them after failed instrumental delivery.

Table 2. Frequency of symptomatic women with pelvic floor dysfunction[1] 6-10 weeks postpartum.

	All participants (n=721)	*Vaginal delivery (n=601)*	*Cesarean delivery (n=120)*	*P- value*[2]
Urinary incontinence[3]	48%	52%	27%	<0.001
SUI	37%	40%	20%	<0.001
UUI	30%	32%	18%	0.002
Anal incontinence	60%	61%	58%	0.6
Flatus incontinence	55%	56%	55%	
Combination of flatus and fecal incontinence	5%	5%	3%	
Prolapse symptoms	29%	33%	12%	<0.001
Sexually active women	55%	53%	65%	0.03
Coital incontinence[4]	3%	3%	3%	1.0
Coital pain[4]	66%	68%	64%	0.5

[1] Answers based on Icelandic translation of the Australian Pelvic Floor Questionnaire (REF)
Analyzed by chi-squared test. Answers represent the number of women who did answer different questions (missing values were 1-4% of answers). [2] P-value for differences between vaginal and caesarean delivery. [3] Of women suffering UI, 132 had mixed UI (both SUI and UUI), 120 in the vaginal delivery group and 12 from the cesarean section group. SUI, stress urinary incontinence; UUI, urgency urinary incontinence. [4] Of sexually active women.

Table 3. Associations between maternal characteristics and delivery outcomes with pelvic floor dysfunction after vaginal delivery (n=601).

	Urinary incontinence			Stress urinary incontinence			Urgency urinary incontinence		
	OR	*(95% CI)*	*P- value*	*OR*	*(95% CI)*	*P- value*	*OR*	*(95% CI)*	*P- value*
Maternal age	1.00	(0.97-1.04)	0.9	1.02	(0.98-1.06)	0.3	1.02	(0.98-1.06)	0.4
Maternal BMI[1]									
BMI <25kg/m^2	1.00			1			1		
BMI 25-≤30kg/m^2	1.06	(0.70-1.61)	0.8	0.99	(0.65-1.51)	1.0	1.03	(0.66-1.61)	0.9
BMI >30 kg/m^2	**1.94**	**(1.20-3.14)**	**0.007**	1.53	(0.96-2.43)	0.08	1.53	(0.94-2.48)	0.09
Birthweight									
≤50th percentile (≤3600 g)	1			1			1		
>50th percentile (>3600 g)	1.16	(0.82-1.65)	0.4	1.08	(0.76-1.53)	0.7	**1.53**	**(1.05-2.21)**	**0.03**
Length of 2nd stage of labor									
≤1 hour	1			1			1		
>1 hour	0.91	(0.64-1.29)	0.6	0.80	(0.56-1.15)	0.2	1.08	(0.74-1.57)	0.7
Anal sphincter tear (3rd and 4th degree, yes vs. no)	1.17	(0.64-2.17)	0.6	1.00	(0.54-1.85)	1.0	1.00	(0.52-1.92)	1.0
Episiotomy (yes vs. no)	0.81	(0.51-1.29)	0.4	0.94	(0.59-1.51)	0.8	0.83	(0.50-1.39)	0.5
Instrumental delivery (yes vs. no)	1.00	(0.64-1.60)	1.0	1.23	(0.78-1.96)	0.4	0.76	(0.46-1.26)	0.3

	Anal incontinence			Prolapse symptoms			Coital pain		
	OR	*(95% CI)*	*P- value*	*OR*	*(95% CI)*	*P- value*	*OR*	*(95% CI)*	*P- value*
Maternal age	1.02	(0.98-1.06)	0.3	1.02	(0.98-1.06)	0.4	0.95	(0.90-1.01)	0.1
Maternal BMI[1]									
BMI <25kg/m^2	1			1			1		
BMI 25-≤30kg/m^2	0.79	(0.52-1.21)	0.3	1.24	(0.80-1.92)	0.3	1.48	(0.76-2.89)	0.2
BMI >30 kg/m^2	0.80	(0.50-1.30)	0.4	0.66	(0.39-1.13)	0.1	0.74	(0.39-1.41)	0.4
Birthweight									
≤50th percentile (≤3.6 kg)	1			1			1		
>50th percentile (>3.6 kg)	1.17	(0.82-1.66)	0.4	0.91	(0.63-1.32)	0.6	0.78	(0.46-1.31)	0.3
Length of 2nd stage of labor									
≤1 hour	1			1			1		
>1 hour	0.90	(0.63-1.29)	0.6	0.99	(0.68-1.45)	0.9	1.38	(0.81-2.33)	0.2
Anal sphincter tear	1.28	(0.67-2.44)	0.5	1.63	(0.87-3.03)	0.1	2.30	(0.47-11.29)	0.3

(3^{rd} and 4^{th} degree, yes vs. no)									
Episiotomy (yes vs. no)	**2.19**	**(1.30-3.67)**	**0.003**	0.81	(0.49-1.35)	0.4	0.89	(0.41-1.92)	0.8
Instrumental delivery (yes vs. no)	1.00	(0.62-1.62)	1.0	0.98	(0.60-1.61)	0.9	1.78	(0.78-4.04)	0.2

[1] BMI (body mass index, kg/m^2) in the first antenatal visit. Reference category for BMI is normal and underweight BMI (<25 kg/m^2, thereof 17 women being underweight (<18.5 kg/m^2 category)).

Table 4. Associations between maternal characteristics and birthweight with pelvic floor dysfunction after cesarean delivery (n=120).

	Urinary incontinence			Stress urinary incontinence			Urgency urinary incontinence		
	OR	*(95% CI)*	*P- value*	*OR*	*(95% CI)*	*P- value*	*OR*	*(95% CI)*	*P- value*
Maternal age	0.96	(0.89-1.04)	0.3	0.95	(0.86-1.04)	0.2	0.97	(0.89-1.07)	0.5
Maternal BMI[1]									
BMI <25kg/m^2	1			1			1		
BMI 25-≤30kg/m^2	1.63	(0.58-4.52)	0.4	0.92	(0.28-3.02)	0.9	1.36	(0.39-4.77)	0.6
BMI >30 kg/m^2	1.25	(0.44-3.44)	0.7	1.26	(0.42-3.81)	0.7	1.78	(0.55-5.75)	0.3
Birthweight									
≤50th percentile (≤3600 g)	1			1			1		
>50th percentile (>3600 g)	0.75	(0.32-1.73)	0.5	0.63	(0.24-1.62)	0.3	0.63	(0.23-1.68)	0.4

	Anal incontinence			Prolapse symptoms			Coital pain		
	OR	*(95% CI)*	*P- value*	*OR*	*(95% CI)*	*P- value*	*OR*	*(95% CI)*	*P- value*
Maternal age	1.02	(0.95-1.09)	0.6	0.90	(0.79-1.01)	0.08	1.0	(0.91-1.08)	0.9
Maternal BMI[1]									
BMI <25kg/m^2	1			1			1		
BMI 25-≤30kg/m^2	0.64	(0.26-1.61)	0.3	0.93	(0.19-4.60)	0.9	1.36	(0.36-5.17)	0.6
BMI >30 kg/m^2	0.87	(0.36-2.08)	0.7	2.69	(0.69-10.59)	0.2	1.02	(0.34-3.03)	1.0
Birthweight									
≤50th percentile (≤3600 g)	1			1			1		
>50th percentile (>3600 g)	1.10	(0.52-2.30)	0.8	0.48	(0.15-1.59)	0.2	1.60	(0.60-4.30)	0.3

[1] BMI (body mass index, kg/m^2) in the first antenatal visit. Reference category for BMI is normal and underweight BMI (<25 kg/m^2, thereof 17 women being underweight (<18.5 kg/m^2 category)).

Article II

GYNECOLOGY

Can postpartum pelvic floor muscle training reduce urinary and anal incontinence?

An assessor-blinded randomized controlled trial

Thorgerdur Sigurdardottir; Thora Steingrimsdottir, MD, PhD; Reynir T. Geirsson, MD, PhD; Thorhallur I. Halldorsson, PhD; Thor Aspelund, PhD; Kari Bø, PhD

BACKGROUND: Pelvic floor dysfunction, including urinary and anal incontinence, is a common postpartum complaint and likely to reduce quality of life.

OBJECTIVE: To study the effects of individualized physical therapist–guided pelvic floor muscle training in the early postpartum period on urinary and anal incontinence and related bother, as well as pelvic floor muscle strength and endurance.

MATERIALS AND METHODS: This was an assessor-blinded, parallel-group, randomized controlled trial evaluating effects of pelvic floor muscle training by a physical therapist on the rate of urinary and/or anal leakage (primary outcomes); related bother and muscle strength and endurance in the pelvic floor were secondary outcomes. Between 2016 and 2017, primiparous women giving birth at Landspitali University Hospital in Reykjavik, Iceland, were screened for eligibilty 6–10 weeks after childbirth. Of those identified as urinary incontinent, 95 were invited to participate, of whom 84 agreed. The intervention, starting at ~9 weeks postpartum consisted of 12 weekly sessions with a physical therapist, after which the main outcomes were assessed (endpoint, ~6 months postpartum). Additional follow-up was conducted at ~12 months postpartum. The control group received no instructions after the initial assessment. The Fisher exact test was used to test differences in the proportion of women with urinary and anal incontinence between the intervention and control groups, and independent-sample *t* tests were used for mean differences in muscle strength and endurance. Significance levels were set as $\alpha = 0.05$.

RESULTS: A total of 41 and 43 women were randomized to the intervention and control groups, respectively. Three participants and 1 participant withdrew from these respective groups. Measurement variables and main delivery outcomes were not different at recruitment. At the endpoint, urinary incontinence was less frequent in the intervention group, with 21 participants (57%) still symptomatic, compared to 31 controls (82%) ($P = .03$), as was bladder-related bother with 10 participants (27%) in the intervention vs 23 (60%) in the control group ($P = .005$). Anal incontinence was not influenced by pelvic floor muscle training ($P = .33$), nor was bowel-related bother ($P = .82$). The mean differences between groups in measured pelvic floor muscle strength changes at endpoint was 5 hPa (95% confidence interval, 2–8; $P = .003$), and for pelvic floor muscle endurance changes, 50 hPa/s (95% confidence interval, 23–77; $P = .001$), both in favor of the intervention group. The mean between-group differences for anal sphincter strength changes was 10 hPa (95% confidence interval, 2–18; $P = .01$) and for anal sphincter endurance changes 95 hPa/s (95% confidence interval, 16–173; $P = .02$), both in favor of the intervention. At the follow-up visit 12 months postpartum, no differences were observed between the groups regarding rates of urinary and anal incontinence and related bother. Pelvic floor- and anal muscle strength and endurance favoring the intervention group were maintained.

CONCLUSION: Postpartum pelvic floor mucle training decreased the rate of urinary incontinence and related bother 6 months postpartum and increased muscle strength and endurance.

Key words: anal incontinence, anal sphincter muscles, pelvic floor muscles, pelvic floor muscle training, postpartum, primiparity, quality of life, short-term, urinary incontinence

Pelvic floor dysfunction (PFD) is common after childbirth, with approximately 30% of mothers experiencing urinary incontinence (UI) and 10% anal incontinence (AI).[1] Sexual concerns, pain, and pelvic organ prolapse (POP) may also occur, with perceptions of bother caused by 1 or more types of PFD reported by 40–91% of primiparous women in the first year postpartum.[2] PFD and sequelae of pelvic floor trauma cause distress and reduce quality of life, including reduced participation in physical activity and exercise.[3,4]

Pelvic floor muscle training (PFMT) in the female population has a 1A evidence level for success in treating UI and is recommended as first-line treatment.[5] Continent women who practiced PFMT during pregnancy (primary prevention) were 62% less likely to experience UI in late pregnancy and had a 29% reduced risk of UI 3–6 months postpartum.[1] However, there are few randomized controlled trials (RCT) on PFMT in the postpartum period, and reports of the effects of PFMT on prevention and treatment of UI and AI are contradictory.[1] Postpartum women who trained the pelvic floor muscles (PFM) had a 50% less prevalence of UI as well as stronger PFMs than a matched control group 6 months postpartum.[6] In contrast, an RCT in which participants were stratified on the presence or absence of major levator ani defects did not show any difference between the PFMT group and controls.[7] A Cochrane review recommended further studies on the influence of PFMT on postpartum UI with the inclusion of AI, which is less frequent and also less well studied.[1]

Our aim in this study was to investigate the effects of individualized, physical therapist–guided postpartum PFMT on the rate of UI and AI, as well as

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AJOG at a Glance

Why was this study conducted?

To provide more knowledge on the effects of postpartum pelvic floor muscle training on urinary and anal incontinence.

Key findings

Urinary incontinence was significantly improved after individually supervised postpartum pelvic floor muscle training, as was perception of bother from this. Anal incontinence and bowel-related bother were not improved. Pelvic floor and anal muscle function were significantly better in the training compared to the control group. The difference in muscle function was maintained at 1 year postpartum.

What does this add to what is known?

The results support the few randomized controlled trials showing short-term effects of pelvic floor muscle training on urinary incontinence and on the pelvic floor and anal muscles. No effect was found on anal incontinence.

related bother and PFM strength and endurance.

Materials and Methods

Study design

This was an assessor-blinded, parallel-group RCT with the allocation ratio 1:1 examining the effects of postpartum PFMT on the rate of UI and AI in primiparous women. The trial was carried out at Tap, Physical Therapy Clinic, Kopavogur, Iceland, from March 2016 to January 2018. Information and baseline assessment of participants were obtained at recruitment 9 weeks postpartum (range, 6−13 weeks), after completed treatment 6 months postpartum (endpoint, range, 5−7 months), and finally 12 months postpartum (follow-up, range, 11−14 months).

The study was approved by the Icelandic National Bioethics Committee (Ref: VSN-13-189), the Data Protection Authority (Ref: 2014030475TS/−) and registered at https://register.clinicaltrials.gov (NCT02682212). The study was conducted in accordance with the Declaration of Helsinki on human experimentation. All participants gave signed informed consent. Maternal and delivery data were extracted from the Icelandic Medical Birth Register.

Participants and randomization

During 2016−2017, first-time mothers with a singleton live birth were approached before discharge from the maternity ward of the university hospital (Landspitali) in Reykjavik. They were asked for permission to be sent an electronic questionnaire about PFD symptoms 6 weeks after delivery. The link to the questionnaire was active for 4 weeks. A total of 95 eligible women were invited to participate through a personal telephone call. They were eligible if they had self-reported postpartum symptoms of UI. AI was also considered to be a primary outcome if present. Participants were required to be generally healthy, aged ≥18 years, able to understand Icelandic, and able to attend the treatment sessions. Exclusion criteria were multiple birth, gestational length <32 weeks, unwell newborn or stillbirth, and conditions that could interfere with the ability to participate (inability to contract their PFMs, neurological conditions, previous urogynecologic and/or bowel surgery, or cognitive disorders). The main outcome assessor (Thorgerdur Sigurdardottir) examined all participants at baseline prior to the randomization.

All women received verbal instructions about how to perform a correct PFM contraction, which was checked with an observation and vaginal palpation of PFM contraction, defined as an inward movement of the perineum and a squeeze around the pelvic openings.[8-10] Measurements of PFM function were then taken with a manometer, the Myomed 932 (Enraf Nonius, Rotterdam, the Netherlands), first with vaginal and consecutively anal air-pressure probes. The device has been tested for test−retest intrarater reliability and has an intraclass correlation coefficient of 0.97 ($P < .001$).[11] Manometry of PFM strength and endurance has been shown to be valid if there is a simultaneous observation of inward movement of the measuring probe.[12] The measurements were standardized, with the women in the lithotomy position, and consisted of vaginal resting pressure, maximal strength (strongest of three 5-second contractions with a 10-second rest in between) and endurance (area under the curve during a 10-second holding period),[13] all given in hPa. The same measurements were performed for anal sphincter function with the women lying on their left side. After this, the clinic's secretary randomly allocated participants to either intervention or control groups using random sequence numbers from an online generator (https://stattrek.com/statistics/random-number-generator.aspx). The Microsoft Excel (Microsoft Corp., Redmond, WA) document containing the randomization was protected with a password and not accessible to the outcome assessor. The secretary was in charge of booking participants for the endpoint and follow-up visits.

Outcome measures

Primary outcomes were rates of urinary and anal incontinence reflecting changes in continence status of self-reported UI, including stress and/or urgency urinary incontinence and AI (fecal and/or flatus incontinence), assessed by the Australian Pelvic Floor Questionnaire (Icelandic translation).[14,15] The questionnaire was translated and pre-tested as described by Beaton et al[16] but was not validated. Women were considered urinary continent if they answered "never" to both of the following questions; "Does urine leak when you rush or hurry to the toilet? Do you not make it in time?" and

"Do you leak with coughing, sneezing, laughing or exercising?" Anal continence was considered as present with a "never" to the following 3 questions: "When you get wind or flatus, can you control it or does wind leak?", "Do you leak watery stool when you don't mean to?" and "Do you leak normal stool when you don't mean to?". Answers "occasionally", "frequently" and "daily" were considered signs of incontinence. Secondary outcomes were bother from bladder and bowel symptoms. Bother was considered absent if answering "not at all" to the questions "How much does your bladder problem bother you?" and "How much does your bowel problem bother you?. Answers "slightly", "moderately" and "greatly" were considered signs of bother. Changes in PFM and anal strength and endurance (secondary outcomes) were measured with the manometer.

Intervention

The intervention consisted of 12 sessions, each 45−60 minutes, and lasted on average 3.7 months (range, 2.6−6.7 months). The participants met once a week with a women's health physical therapist. If they cancelled, a new appointment was given so as to fulfill 12 sessions. The NeuroTrack Simplex biofeedback device with vaginal sensors was used to facilitate the PFMT (Quintet, Bergen, Norway). Treatment was individualized to suit each woman's ability within a protocol encouraging 10 close-to-maximum contractions and 7-second holding periods with a 10-second rest between contractions. During the first 2 appointments, women were instructed to perform 2 sessions with a rest in between and thereafter 3 times 10 contractions if possible during each visit. Participants were encouraged to progress by using the biofeedback device and to relax their PFMs by diaphragmatic breathing between contractions. During appointments 8 and 9, the women were encouraged to add 3 rapid contractions at the end of each contraction and to do so in the remaining sessions.[6,17] Intervention group women were asked to do home exercises of 10 close-to-maximum PFM contractions, 3 sets per day and to use the "knack" (ie, precontracting the PFM before coughing and sneezing). They were provided with an exercise diary to register adherence to the home training and were encouraged in every office session to follow the protocol during the intervention period.

The endpoint assessment was carried out within 1 week after completion of the 12 sessions. Follow-up assessment was scheduled 1 year after the childbirth. At the endpoint and follow-up occasions, women answered the questionnaire again, and PFM and anal muscle function were reassessed. During the follow-up, participants also answered a separate questionnaire about PFMT adherence. The controls had no further follow-up after recruitment with general instructions and assessment of PFM contractions, but were not discouraged from performing PFM exercises. The main assessor was blinded to group allocation throughout the study.

Sample size calculation

This was based on a previous study in which a 67% vs 34% reduction in the prevalence of UI was found in the intervention and control groups.[6] With a power of 0.8 and 2-sided significance of $P < .05$, a total of 40 women were needed in each group, accounting for 5% dropout.

Statistical analysis

SPSS version 24 software (IBM Corp., Armonk, NY) was used for statistical analysis. Characteristics of participants are reported, with measures of central tendency or counts with percentages. Normally distributed continuous variables are presented as means with standard deviations (SD) or 95% confidence intervals (95% CI) and skewed continuous variables, namely, first and second stages of labor with median and 10th−90th percentiles. The study was analyzed per protocol. Rates of incontinence and perception of bother were analyzed by the Fisher exact test. An independent sample t test was used to compare differences between groups in PFM strength and endurance and the Mann−Whitney U test for stages of labor. Significance levels were set to .05.

Results

In all, 84 women, all of white ethnicity, were included, 41 in the intervention group and 43 in the control group. The initial appointment was on average 9 weeks postpartum (range, 6−13 weeks). Participant characteristics at recruitment/baseline are shown in Table 1. At baseline, 16 participants (19%) had difficulties activating their PFMs, but all were able to do this after verbal instruction and facilitation through vaginal palpation. Four women (3 from the intervention group) withdrew after the initial evaluation. Five women from the intervention group who did not attend the intervention, and 4 of the controls, did not participate in the endpoint pelvic floor assessment but agreed to answer the questionnaires and thus contribute to primary outcomes and secondary outcomes of bother (Figure 1). Women who dropped out were slightly younger than participating women and had smaller infants. Other characteristics and delivery outcomes were not different between participating and nonparticipating women. In all, 33 of the 41 women who attended the intervention completed all 12 sessions with the physical therapist. No adverse treatment effects were reported. The timeline of the study is shown in Figure 2.

Primary outcome measures

All participants were urinary incontinent on recruitment. Results for primary and secondary outcomes at endpoint are shown in Table 2. The intervention had a significant impact on urinary incontinence ($P = .03$) at the endpoint (~6 months postpartum), with fewer women, 21 urinary incontinent women (57%) in the intervention group compared with 31 (82%) in the control group. However, the intervention had no effect on the rate of anal incontinence, with 21 (58%) in the intervention group and 27 (71%) in the control group experiencing anal incontinence at endpoint ($P = .33$).

TABLE 1
Characteristics of included participants with postpartum incontinence at recruitment and delivery outcomes

	Intervention group (n = 41)	Control group (n = 43)	*P* value
Outcome variables			
Urinary incontinence, n (%)	41 (100%)	43 (100%)	
Bladder-related bother[a], n (%)	22 (55%)	22 (52%)	.83
PFM strength, hPa, mean (SD)	17 (11)	17 (10)	.94
PFM endurance, hPa/s, mean (SD)	119 (92)	115 (90)	.81
Anal incontinence, n (%)	26 (63%)	33 (77%)	.24
Bowel-related bother[a], n (%)	26 (63%)	32 (74%)	.35
Anal sphincter strength, hPa, mean (SD)	59 (32)	56 (32)	.73
Anal sphincter endurance, hPa/s, mean (SD)	358 (229)	323 (215)	.48
Maternal characteristics			
Age, y, mean (SD)	28 (4.3)	29 (5.3)	.19
BMI at recruitment, mean (SD)	26 (4.3)	27 (4.5)	.36
Weeks from delivery to recruitment, mean (SD)	9 (1.3)	9 (1.6)	.41
Breastfeeding, n (%)	38 (93%)	39 (91%)	.74
Smoking, n (%)	0 (0%)	2 (5%)	.17
Pregnancy variables and delivery outcomes			
Weight changes in pregnancy, kg, mean (SD)	14 (6.5)	15 (5.7)	.52
Gestational length, wk, mean (SD)	39.7 (1.2)	39.7 (1.5)	.98
Vaginal delivery, n (%)	37 (90%)	42 (98%)	.20
Induction of labor	11 (30%)	11 (26%)	
Instrumental delivery			
Vacuum	5 (14%)	7 (17%)	
Forceps	2 (5%)	1 (2%)	
Obstetric anal tear 3rd–4th degree	3 (8%)	5 (12%)	
Episiotomy	7 (19%)	4 (10%)	
Epidural anesthesia in vaginal delivery	19 (51%)	21 (50%)	
Length of first stage of labor, hh:mm[b]	9:35 (3:54-22:50)	11:15 (5:17-22:58)	.32
Length of second stage of labor, hh:mm[b]	1:02 (0:17-2:48)	1:43 (0:25-2:58)	.13
Cesarean delivery, n (%)			
Emergency[c]	2 (5%)	1 (2%)	
Elective	2 (5%)	0 (0%)	
Birthweight, g, mean (SD)	3547 (487)	3668 (544)	.29
Head circumference, cm, mean (SD)	35 (1.3)	36 (1.4)	.18

Independent-samples *t* test for continuous normally distributed variables, Fisher's exact test for nominal variables.

BMI, body mass index; *PFM*, pelvic floor muscles; *SD*, standard deviation.

[a] Missing values for 1 individual in each group; [b] Presented as hour to hour and minute to minute (hh:mm), median with 10th–90th percentile of non–normally distributed variables, compared with Mann–Whitney *U* test; [c] In each group, 1 emergency cesarean delivery was performed after induction of labor.

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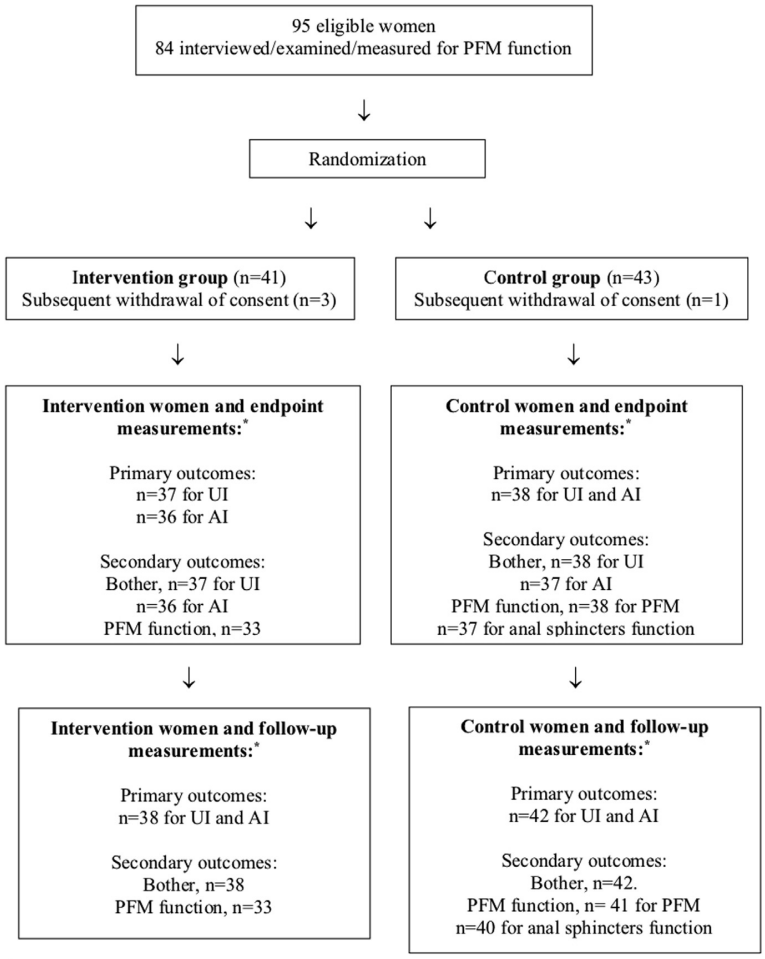
Secondary outcome measures

Bladder- and bowel-related bother were not different between groups at recruitment. At endpoint, significantly fewer intervention group women reported bothersome bladder symptoms compared to controls (10 [27%] vs 23 [60%, $P = .005$). The difference in bother from bowel symptoms at endpoint was not significant (17 [47%] from the intervention group vs 19 [51%] of controls, $P = .83$).

FIGURE 1
Consolidated Standards of Reporting Trials (CONSORT) flow diagram of study participation, by outcome variables



* Different number of participants were willing to participate in measurements on different occasions throughout the study as well as answering different number of questions in the questionnaires.

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There were no differences between groups regarding PFM and anal sphincter strength and endurance at recruitment. The mean difference between groups in measured PFM strength changes at endpoint was 5 hPa (95% CI, 2−8; $P = .003$), and for PFM endurance changes, 50 hPa/s (95% CI, 23−77; $P = .001$), both in favor of the intervention. The mean between-group difference at endpoint for anal sphincter strength changes was 10 hPa (95% CI, 2−18; $P = .01$), and for anal sphincter endurance changes, 95 hPa/s (95% CI, 16−173; $P = .02$), both in favor of the intervention (Table 2).

Outcomes at 12-month follow-up

There were no significant differences in the rate of urinary incontinence (28 intervention [76%], 34 controls [81%], $P = .60$) or women with anal incontinence (23 intervention [60%], 26 controls [62%], $P = 1.0$) at follow-up. Bother from bladder or bowel symptoms was also not different ($P = .82$ and $P = .11$, respectively). Increases in PFM and anal sphincter strength and endurance were similar between groups from endpoint to follow-up, where the intervention group still had increased their PFM and their anal strength and endurance significantly more than the controls. Follow-up measurements are detailed in Table 3.

Adherence to pelvic floor muscle training

Women who returned their exercise diary (n = 11, 33%) reported doing 10 PFM exercises 1−4 times per day and for ≥3 days per week during the intervention. In other cases, the diary was lost or exercises were not documented.

At the 1-year follow-up, 42 women in the control group (100%) reported retrospectively about PFM exercises; 8 (19%) had exercised ≥3 times per week from recruitment to endpoint (6 months), and others less or not at all. From endpoint to follow-up, 6 control subjects (14%) continued exercising ≥3 times per week. Ten of the 38 women in the intervention group reported PFM exercises ≥3 times per week (26%) from endpoint to follow-up.

Comment

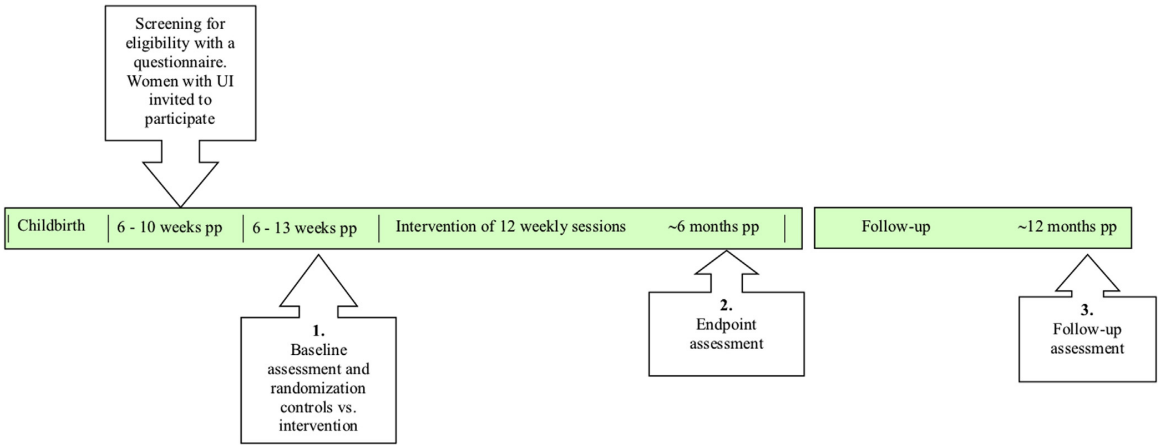
Principal findings

Among women with urinary incontinence after childbirth, we showed that regular pelvic floor muscle training substantially reduced the rate of UI and related bother. Pelvic floor muscle strength and endurance were also improved. However, no differences were observed for anal incontinence and bowel-related bother between groups. At the 1-year follow-up, similar prevalences of urinary and anal incontinence were observed, whereas improvements in PFM and anal sphincter strength and endurance persisted.

Comparison with results from previous studies

Precise comparison with similar studies is often difficult, because selection of participants, study designs, interventions, intensity, and intervention periods, as well as selection of outcome measures, are seldom the same. Our results are in line with some studies

FIGURE 2
Timeline of the study, showing planned recruitment, end of treatment (endpoint), and follow-up assessment times



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regarding the influence of postpartum PFMT on UI[6,18,19] and on bladder-related quality of life.[19] Individual vs group training seem to be equally effective, but improvement may be related to the amount of contact with the healthcare provider.[20] In our and most other studies, teaching and assessment of PFM contractility are included to ensure correct performance.[12] This may explain minimal differences between the intervention and control groups in some studies, because teaching and assessing PFM function are strong interventions in themselves and can encourage the control women to exercise. PFMT is seldom discouraged for the control group[6,19] with the exception of the study of Dumoulin et al, where women in the control group received a relaxing massage and were discouraged from doing PFM exercises.[21] Two other RCTs had a different intervention format, in which a healthcare provider told and encouraged the women to exercise their PFM. Both studies showed positive results on UI.[22,23]

TABLE 2
Primary and secondary outcomes at endpoint 6 months postpartum

Outcomes at endpoints	N intervention/ control[a]	Intervention group n (%)	Control group n (%)	*P* value[b]
Urinary incontinence[c], n (%)	37/38	21 (57%)	31 (82%)	.03
Bothered by urinary symptoms[c], n (%)	37/38	10 (27%)	23 (60%)	.005
PFM strength[d], mean (SD)	33/38	29 (14)	24 (13)	.003
PFM endurance[d], mean (SD)	33/38	234 (122)	180 (117)	.001
Anal incontinence[c], n (%)	36/38	21 (58%)	27 (71%)	.33
Bothered by bowel symptoms[c], n (%)	36/37	17 (47%)	19 (51%)	.83
Anal sphincter strength[d], mean (SD)	33/37	84 (31)	71 (34)	.01
Anal sphincter endurance[d], mean (SD)	33/37	578 (272)	450 (237)	.02

Strength of PFM and anal sphincters is measured as squeeze pressure in hPa. Endurance of PFM and anal sphincters is in hPa/s.

PFM, pelvic floor muscles; *SD,* standard deviation.

[a] Different numbers of women participated in PFM and anal sphincter measurements, and some did not answer all questions in the questionnaire; [b] *P* values for PFM and anal strength and endurance at endpoint show significant changes from recruitment to endpoint; [c] Fisher exact test; [d] Independent-samples *t* test.

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TABLE 3
Primary and secondary outcomes at follow-up 12 months postpartum

Outcomes at follow-up	Intervention/ control[a], n	Intervention group n (%)	Control group n (%)	*P* value[b]
Urinary incontinence[c], n (%)	38/42	28 (76%)	34 (81%)	.60
Bothered by urinary symptoms[c], n (%)	38/42	17 (45%)	17 (41%)	.82
PFM strength[d], mean (SD)	33/41	32 (15)	27 (14)	.03
PFM endurance[d], mean (SD)	33/41	255 (130)	201 (116)	.002
Anal incontinence[c], n (%)	38/42	23 (60%)	26 (62%)	1.00
Bothered by bowel symptoms[c], n (%)	38/42	11 (29%)	20 (48%)	.11
Anal sphincter strength[d], mean (SD)	33/40	91 (34)	77 (35)	.008
Anal sphincter endurance[d], mean (SD)	33/40	618 (267)	504 (266)	.04

Strength of PFM and anal sphincters is measured as squeeze pressure in hPa. Endurance of PFM and anal sphincters is in hPa/sec.

PFM, pelvic floor muscles; *SD*, standard deviation.

[a] Different numbers of women participated in PFM and anal sphincter measurements. Some did not answer all questions in the questionnaire; [b] *P* values for PFM and anal strength and endurance show significant changes from recruitment to follow-up; [c] Fisher exact test; [d] Independent-samples *t* test.

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One study did not show positive results of PFMT for UI, which could have been caused by the planned inclusion of women with major levator ani defects or by a type II error.[7] The study followed the same protocol as that of Mørkved and Bø.[6] Hence, the training dosage was the same.

At least 2 studies have shown positive findings regarding reduced AI in women undergoing postpartum PFMT.[22,24] In both studies, participants had fewer appointments with the healthcare provider and began later after the childbirth, but the interventions lasted longer than in our study. Both studies likely had sufficient power to detect changes in continence status.[22,24] As not all participants in our study presented with AI, the study may have lacked power to detect AI changes.[24] However, the intervention increased PFM and anal sphincter strength and endurance, and therefore had the potential to reduce AI. The most recent Cochrane review concluded that more RCTs are needed regarding the effect of PFMT on AI in postpartum women.[1]

There is a lack of studies including long-term follow-up, both for UI and for AI. In our study the number of urinary incontinent intervention group women increased from endpoint (after end of treatment sessions) to the final follow-up. Answers from the questionnaires also showed that few women continued to exercise their PFMs after the intervention stopped. This suggests the need for strategies to motivate women to continue to exercise their PFMs beyond the first postpartum months. Other studies, when following participants longer than during the mere intervention, have shown that urinary incontinence tends to recur to some extent with time in the absence of PFMT.[22,23,25] There are many challenges related to long-term follow-up of the PFMT effect on women in their childbearing years, when they have new roles to adapt to and must deal with sleep deprivation, physical, hormonal, and emotional changes, as well as additional pregnancies.[26]

Clinical implications

Our results show benefits from PFMT, in which the treatment aiming at enhancing muscle function in the pelvic floor had a positive effect on bothersome symptoms of urinary incontinence. Even though we did not detect positive effects on anal incontinence, women may increase their body awareness, improve structural support for the pelvic organs, and achieve faster automatic contractions of the PFM.

Research implications

Pelvic floor muscle training is effective and helps women with bothersome symptoms from the pelvic floor in the first months after childbearing. This study is 1 of few with follow-up data after cessation of the intervention, and shows the need for more continued training after childbirth. Further studies are warranted to find ways to motivate and encourage women to perform pelvic floor muscle exercises regularly over a longer postpartum period.

Strengths and limitations

Strengths of our study were the randomized and blinded design, an individually supervised program for each participant aiming at treatment of symptoms and high adherence to the intervention sessions, as well as following the participants for 1 year.

Limitations were a higher drop-out rate in the intervention group and a lack of power to detect changes regarding AI. Clinical measures of leakage such as pad testing would have cast additional light on urinary incontinence.

Conclusion

Supervised postpartum PFMT decreased the number of women who were urinary incontinent by the end of treatment, but continence rates were not fully sustained by 12 months postpartum. Anal continence rates were not altered. ■

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Article III

Do female elite athletes experience more complicated childbirth than non-athletes? A case–control study

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ABSTRACT

Objective Previous studies have suggested that female athletes might be at higher risk of experiencing complications such as caesarean sections and perineal tears during labour than non-athletes. Our aim was to study delivery outcomes, including emergency caesarean section rates, length of the first and second stages of labour and severe perineal tears, in first-time pregnant elite athletes compared with non-athletes.

Methods This is a retrospective case–control study comparing birth outcomes of primiparous female elite athletes engaging in high-impact and low-impact sports compared with non-athletic controls. The athletes had prior to birth competed at a national team level or equivalent. Participant characteristics and frequency of training for at least 3 years before a first pregnancy were collected via a self-administered questionnaire. Information on delivery outcome was retrieved from the Icelandic Medical Birth Registry.

Results In total, 248 participated, 118 controls, 41 low-impact and 89 high-impact elite athletes. No significant differences were found between the groups with regard to incidence of emergency caesarean section or length of the first and second stages of labour. The incidence of third-degree to fourth-degree perineal tears was significantly higher (23.7%) among low-impact athletes than in the high-impact group (5.1%, p=0.01), but no significant differences were seen when the athletes were compared with the controls (12%; p=0.09 for low-impact and p=0.12 for high-impact athletes).

Conclusion Participation in competitive sports at the elite level was not related to adverse delivery outcome, including length of labour, the need for caesarean section during delivery and severe perineal tears.

What are the findings?

- Frequency and type of exercise are not associated with complications in childbirth.
- Athletes participating in high-impact sports do not experience more severe obstetric perineal tears than non-athletic women.
- Emergency caesarean section rates and the length of the first and second stages of labour are not influenced by sports impact.

How might it impact on clinical practice in the future?

- Healthcare providers and coaches may explain to high-impact athletes that childbirth is not likely to have more effect on their pelvic floor than other women.
- Caregivers and coaches around female athletes should encourage them to exercise their pelvic floor muscles during and after pregnancy.

INTRODUCTION

Current guidelines encourage pregnant women to participate in aerobic and other strengthening exercises, as well as to practise specific strength training of the pelvic floor muscles (PFMT).[1–3] Previous studies have suggested that participation in high-impact, high-intensity sports might lead to hypertrophy of the pelvic floor muscles (PFM) to the extent of causing obstruction for the passing fetus and thus prolonging the second stage of labour.[4 5] Based on this it can been hypothesised that hypertrophied PFMs could be associated with adverse outcomes in labour, such as severe perineal tears (third to fourth degree) and failure to progress in labour, resulting in higher rates of emergency caesarean sections (CS). However, the IOC expert group has revealed a significant lack of high-quality evidence specific to pregnant elite athletes and the impact of strenuous exercise during pregnancy on labour and childbirth.[6]

Sports activities are usually divided into those involving *high impact*, defined as activities where both feet are above the floor (running and jumping), such as in ball games, running or gymnastics, or *low impact* (one or both feet are on the ground all the time), such as golf, cross-country skiing, weightlifting or swimming (with minimal gravitational influence).[7] Participation in high-impact and low-impact sports could thus have a different influence on labour and birth outcomes. In an IOC review article, Bø *et al* specifically highlighted the need for research on the prevalence of, and risk factors for, maternal and perinatal outcomes in elite athletes and how these compare with estimates for the general population. Prolonged labour, emergency CS and severe perineal tears (third to fourth degree) were specifically mentioned as important variables for assessing this claim.[8]

The aim of the present study was to compare the incidence of emergency CS, third-degree to fourth-degree perineal tears, and the length of the first and second stages of labour between elite athletes who participated in either high-impact or low-impact sports using as a control group women who were only physically active at a recreational level. Furthermore, we aimed to study the

association between delivery outcome and exercise training frequency before and during the first pregnancy in elite athletes.

METHODS

Design

This was a retrospective case–control study comparing data from before and during the first pregnancy and childbirth of two groups of female elite athletes and one female non-athletic group.

Participants and data collection

Data were collected over a 1-year period from November 2015 to 2016. We identified elite athletes through Icelandic sports federations and public/social media. The athletes who agreed to participate helped in recruiting more eligible athletes and women to form the non-athletic control group. Requests for participants were also mediated through social media. The elite athletes were grouped by low-impact and high-impact sports.[7]

All the athletes had competed in the highest division possible or were professional athletes (like ballroom dancers) in their sport or at a national team level (58% in national teams) for at least 3 years before their first pregnancy. With regard to CrossFit, which is not included as an Olympic sport,[9] most of the participants had competed in international tournaments. Participants in the non-athletic group did not compete in sports and had only been physically active at a recreational level before and during their first pregnancy.

Inclusion criteria for the study were a healthy mother, singleton first pregnancy, and able to understand Icelandic or English, while all women with high-risk pregnancy, such as gestational hypertension, pre-eclampsia or multiple pregnancy, were excluded.

Participants were initially contacted by telephone and subsequently sent information about the study through email.

Questionnaire

All participants answered an electronic questionnaire regarding background and type of sport if any, frequency of training (hours/week), both specific sports training and/or other regular training classified as strength, endurance and/or flexibility training, and the number of years in the highest division possible and/or in the national team before and during their first pregnancy.

Outcome assessment

Information on pregnancy outcomes was extracted from the Icelandic Medical Birth Registry. Participants' maternity record details were retrieved electronically and included maternal age in years, height in centimetres, weight in kilogram and body mass index (BMI) in kg/m^2 at the first antenatal visit, mode of delivery, duration of the first and second stages of labour in minutes, degree of perineal tears, use of episiotomy, anaesthesia/epidural, birth weight in grams, and length and newborn head circumference in centimetres. In some cases (n=11) the athletes had delivered their child while living abroad. In those cases, the women scanned and emailed their original medical birth records. Emergency CS in Iceland is defined as a decision for CS taken within 8 hours of the delivery time.

Statistics

Statistical analysis was performed using SAS version 9.4, R and Stata version 14 software. The characteristics of the study participants were described by frequencies and percentages for dichotomous outcomes. The median with 10th−90th percentiles was used to describe skewed continuous variables, while the mean and SD were used to describe normally distributed variables.

χ^2 test was used to compare delivery outcome for emergency CS and third-degree to fourth-degree perineal tears and Kruskal-Wallis for length of first and second stages of labour for the three groups. Penalised multiple logistic regression analysis with the Firth small-sample bias-reduction method[10 11] was applied to estimate the association with predictor variables and impact groups. OR with 95% CI was calculated for the third-degree and fourth-degree perineal tears. The results from the three models were presented: (1) unadjusted, (2) adjusted for maternal age, BMI and training frequency, and (3) model 2 with additional adjustment for birth weight. P values <0.05 were considered significant.

RESULTS

Background information

In total, 248 of the 293 women invited filled in and returned the questionnaire (84%) (figure 1).

Table 1 shows the characteristics of study participants. All groups were significantly different from each other with regard to frequency of training (hours/week) before their first pregnancy, where the low-impact group exercised more than the high-impact group, the non-athletic control group being the least active. Training frequency and months of training during pregnancy were not different between the athletic groups, but lower in the non-athletic group. The non-athletic women had significantly higher BMI than women in both athletic groups. Birth weight was significantly higher in the low-impact group compared with the non-athletes. The low-impact group had significantly longer time from childbirth to recruitment than both other groups.

Table 2 shows the details of group composition. The non-athletic control group consisted of 118 women, the low-impact group 41 women and the high-impact group 89 women.

Impact groups and delivery outcome

There were three elective CS, one in each group. In the high-impact group, the indication was transverse lie and fibromyoma, in the low-impact group fear of childbirth and in the control group breech presentation. For intergroup comparisons of delivery outcomes, these women were omitted.

Table 3 shows the delivery outcome. The number of emergency CS was not statistically different between groups: 9, 2 and 10 for the non-athletes, low-impact and high-impact groups, respectively (p=0.51). The length of the first and second stages of labour was not significantly different between the groups either (p=71 and p=0.22, respectively). There were 98 missing values for the first and 28 missing values for the second stage of labour in the birth registry, and this information could not be added when searched for in the actual maternity records.

The incidence of third-degree and fourth-degree perineal tears was significantly higher (23.7%) among low-impact athletes than among the high-impact group (5.1%, p=0.01), but when each athletic group was compared with controls (12%), neither group reached significance, that is, p=0.09 for low-impact and p=0.12 for high-impact athletes. Figure 2 shows the proportion of women with third-degree and fourth-degree tears by impact group. After adjusting for maternal age, BMI and training frequency, high-impact athletes still had lower risk of third-degree and fourth-degree tears compared with controls (OR (95% CI) 0.6 (0.1 to 2.5)), and the risk observed for low-impact athletes was higher (OR (95% CI) 3.6 (0.8 to 17.1)) (table 3). However, neither athletic group reached statistical significance

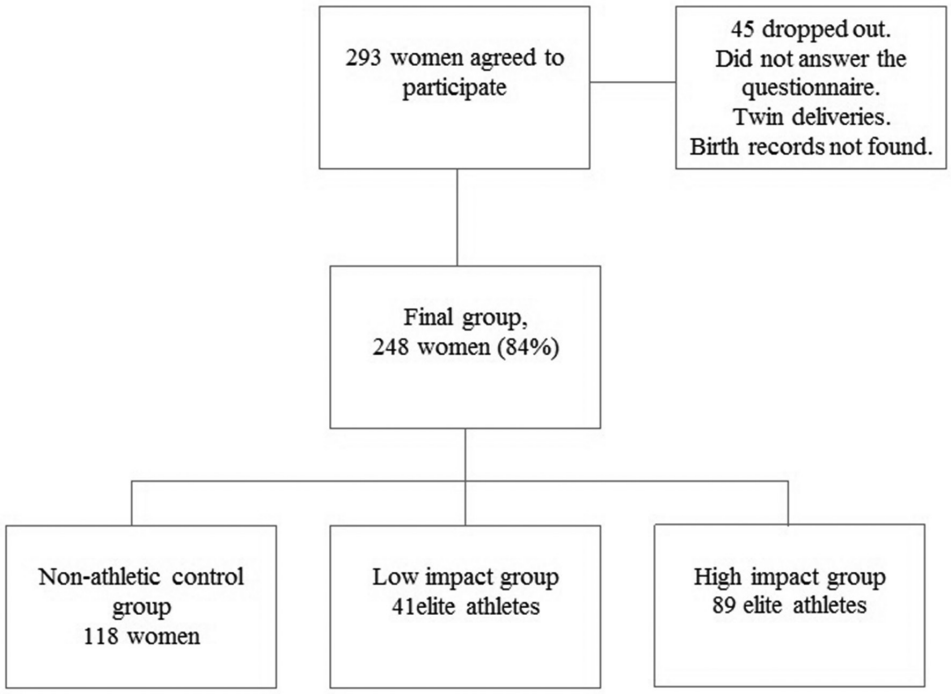

Figure 1 Flow chart of participants.

when compared with controls. Adjustment for birth weight did not have an effect on the results. Penalised multiple logistic regression showed that frequency of exercise before and during pregnancy, maternal age and BMI had no significant association with any delivery outcome.

DISCUSSION

We found no association between the length of the first and second stages of labour or a higher incidence of emergency CS and participation in high-impact or low-impact sports. Interestingly the high-impact elite athletes had a lower incidence of third-degree to fourth-degree perineal tears than the low-impact group. Participation in high-impact sports seemed not to influence the incidence of severe perineal tears in a negative way. Frequency of exercise training itself before and during the first pregnancy did not show relation to any subsequent delivery outcome. Regular, more frequent and high-impact exercise during pregnancy has, however, been shown to reduce the need for emergency caesarean delivery in women having their first baby.[12]

Our results regarding the length of the first and second stages of labour are in line with the analysis by the IOC expert

Table 1 Characteristics and past exercise habits (specific sports women engage in and additional training) at recruitment of study participants, presented for each period separately (mean and SD)

	Non-athletics (n=118)	Low-impact (n=41)	High-impact (n=89)	P values
Maternal				
Age at delivery (years)	26.0 (4.0)	26.7 (4.2)	27.2 (3.6)	0.21
Prepregnancy body mass index (kg/m^2)	25.5 (5.7)	23.6 (3.0)	22.7 (2.8)	<0.001
Height (cm)	168.8 (6.5)	170.0 (6.6)	169.9 (6.1)	0.4
Neonatal				
Birth weight (kg)	3.5 (0.6)	3.7 (0.4)	3.6 (0.5)	0.02
Head circumference (cm)	35.1 (2.1)	36.0 (1.3)	35.6 (1.3)	0.009
Training				
Time from delivery to replies (years)	3.4 (15.0)	5.4 (16.7)	3.3 (15.7)	0.008
Training for ≥3 years prior to pregnancy (hours/week)	1.6 (3.2)	20.3 (10.7)	14.3 (4.3)	<0.0001
Training during pregnancy (hours/week)	0.2 (1.2)	10.2 (12.7)	8.5 (7.4)	<0.0001
Gestational month training stopped	0.2 (1.2)	3.8 (3.9)	4.4 (3.8)	<0.0001
Years in highest division	0 (0)	8.7 (5.5)	8.4 (4.7)	<0.0001

Table 2 Classification of participants by type of sport prior to pregnancy

	n	%
Non-athletic women	118	47.5
Low-impact athletes	41	16.5
Swimming	16	6.5
Golf	10	4
Riding/jockey	5	2
Weightlifting	5	2
Ballroom dancing	3	1.2
Motocross	1	0.4
Pole fitness	1	0.4
High-impact athletes	89	35.9
Track and field	24	9.7
Football (soccer)	19	7.7
Basketball	13	5.2
CrossFit	10	4
Team gymnastics	9	3.6
Handball	8	3.2
Racket sports (tennis, badminton)	4	1.6
Self-defence sports (judo, karate)	2	0.8

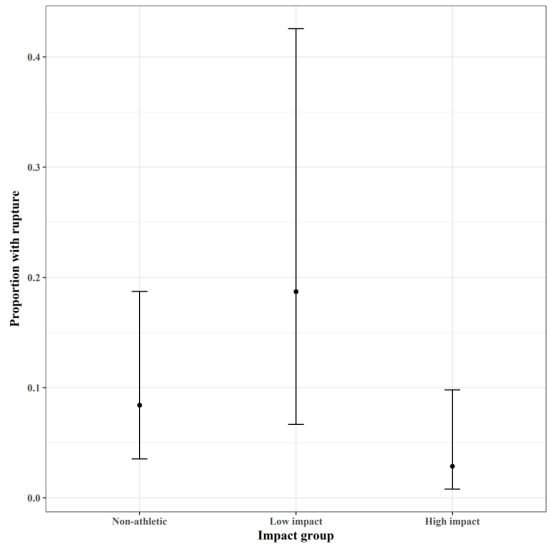

Figure 2 Proportion of vaginal births with third-degree and fourth-degree perineal ruptures by groups, probability with 95% CI.

committee. There is moderate evidence supporting that physical activity does not increase the length of labour, and in our study this also applied to elite athletes.[6] It was unfortunate that many values were missing in registration on the length of labour, particularly for the first stage of labour in our case, but these missing data were quite evenly distributed among the three groups.

In this study we found no significant differences in emergency CS rates among the groups. The incidence was relatively low, ranging from 5% to 11% of the total number of participants in the groups. It may therefore be assumed that participating in sports at elite level does not increase the risk for emergency CS. The IOC expert committee found that the results from multiple studies regarding CS rates and exercise were inconsistent and no studies on elite athletes were found.[6] That the section rates in general are lowered when women exercise was recently shown in a large Norwegian study,[12] and our results support that participating in sports at elite level does not increase the risk for emergency CS.

Because the low-impact group was smaller than the other two, comparisons become less precise regarding the results for that group. This could explain the high incidence of third-degree to fourth-degree perineal tears (23.7%). In comparison the incidence among primiparas in Iceland for the years 2012–2016 was 6.6%–7.2%.[13] This smaller group of women requires further study, including five weightlifters and five horseback riders, sports that are of interest with regard to their impact on the pelvic floor. Considering the sample size, our results must be

Table 3 Caesarean sections, length of labour stages and perineal tears by exercise/impact group and associations between impact group in women with vaginal delivery

	Non-athletic	Low-impact	High-impact	P values*
Caesarean sections	n=10	n=3	n=11	
Elective (n)	1	1	1	0.51
Emergency (n)	9	2	10	
Vaginal delivery	n=108	n=38	n=78	
Length of labour stages (min)				
First stage of labour*†	603 (231–1069)	613 (331–1017)	600 (296–1386)	0.71
Second stage of labour*‡	57 (17–116)	56 (32–106)	65 (23–153)	0.22
Degree of perineal tears, n (%)				
None to second degree	95 (88)	29 (76.3)	74 (94.9)	0.01
Third to fourth degree	13 (12)	9 (23.7)	4 (5.1)	
Unadjusted OR (95% CI)	1	2.3 (0.9 to 5.8)	0.4 (0.1 to 1.3)	0.01
Adjusted OR (95% CI)§	1	3.6 (0.8 to 17.1)	0.6 (0.1 to 2.5)	0.01
Adjusted OR (95% CI)¶	1	2.4 (0.5 to 12.8)	0.4 (0.1 to 1.7)	0.01

*Testing the null hypothesis that all three groups are equal. χ^2 test was used in all cases, except for length of the second stage of labour where Kruskal-Wallis test was used.
†For the first stage of labour, there were 50, 14 and 34 missing values for the non-athletic, low-impact and high-impact women, respectively (median, 10th–90th percentile).
‡For the second stage of labour, there were 8, 10 and 10 missing values for the non-athletic, low-impact and high-impact women, respectively (median, 10th–90th percentile).
§Adjusted for maternal age, BMI and training frequency.
¶Adjusted for maternal age, BMI, training frequency and birth weight.
BMI, body mass index.

interpreted with caution. Although most of the childbirths took place less than 5 years before the study, the time of first childbirth for some of the participants went back to year 2000. Therefore, we had a risk of recall bias regarding exercise training. Exercise training frequency was self-reported and not measured, and this may make the data subject to overestimation.[14] However, the life of an elite athlete revolves around sport and competition, and therefore it is not unlikely that most remember quite well how they exercised even many years back. Exercise training was only documented as frequency (hours/week) and we had no information on intensity. We do not know how fast the athletes ran or swam or how much weight they lifted. Despite this, the athletes were among the best in their sports in Iceland or even internationally, and therefore we can infer that it is likely that they did exercise intensively.

Limited information is available on this subject from other studies. Kruger *et al*[5] concluded that participation in high-impact sports might influence the properties of the pelvic floor to the extent of causing obstruction for the passing fetus without having actual delivery information from athletes. They hypothesised that repetitive jumping and landing could possibly increase the PFM mass. Our results did not confirm this hypothesis neither for the length of the second stage of labour or rate of severe perineal tears, both of which could be influenced by the pelvic floor strength. The high-impact athletes in our study seemed to have more favourable delivery outcomes regarding their pelvic floor than the control group, even though this did not reach statistical significance. In a later article from 2007, Kruger *et al* proposed, however, that emphasis would be placed on further studies on the properties of the PFM in elite athletes.[4] A recent study of PFM strength in elite female athletes, almost entirely high-impact compared with non-athletes, showed no significant difference in strength between the groups.[15] In a small comparison study of female handball, volleyball, basketball players and controls, it was found that volleyball and basketball players had significantly weaker PFM than the controls.[16] It is not possible to infer that increased strength or volume of the PFM is associated with delivery outcome or that female athletes have stronger PFM than other women. According to Du *et al* PFMT during pregnancy was not found to have a negative influence on labour—on the contrary specific PFMT reduced the length of the first and second stages of labour.[17] Similarly, Bø *et al* found that women who exercised regularly during pregnancy had a wider levator hiatus at 37 gestational weeks, which in turn may lead to easier birth.[18] In the IOC review article no specific studies among elite athletes on the length of labour or regarding perineal tears were identified.[6] The few studies on elite athletes have used cross-sectional and retrospective designs,[6] resulting in low to moderate levels of evidence. Our results must also be interpreted with that in mind.

Strengths and limitations

The strengths of the present study are the inclusion of a high number of elite athletes, the high response rate and the use of a control group. The limitations were the retrospective design with a risk of recall bias and the differing number of participants between groups. Lack of significant results may also be due to the study being underpowered (type II error). Prospective studies on elite athletes are difficult to perform due to an infrequency of pregnancy in athletes competing at the national or international level at any given time and the geographical challenges of enrolling these women in prospective studies.

CONCLUSIONS

Participation in sports at elite level is not associated with higher rates of emergency CS, prolonged second stage of labour or third-degree to fourth-degree perineal tears. Prospective studies on elite female athletes regarding birth outcome would be desirable, but meanwhile summative evidence from retrospective design may add to our knowledge and guide further research.

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Patient consent Not required.

Ethics approval Ethical approval was obtained from Icelandic National Bioethics Committee (Ref: VSN-13–189), and the Data Protection Authority granted permission as well (Ref: 2014030475TS/--). The study was conducted in accordance with the Helsinki Declaration on human experimentation.

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Appendices

All Appendices were answered electronically, through an e-mail or in a computer when attending appointments with a physical therapist (Study II).

In all cases, new questions opened depending on the previous question answered. For instance if answering “no” participants did not have to go through irrelevant questions that were related to answering “yes”. This means that the women in all studies only answered the questions that related to their status or condition.

Appendix 1

The Australian Pelvic Floor Questionnaire (English version)

Bladder section

Q1 How many times do you pass urine in the day? [ ] up to 7 [ ] between 8 – 10 [ ] between 11 – 15 [ ] > 15	**Q2** How many times do you get up at night to pass urine? [ ] 0 – 1 [ ] 2 [ ] 3 [ ] > 3	**Q3** Do you wet the bed *before* you wake up at night? [ ] never [ ] occasionally (< 1 x week) [ ] frequently (≥ 1 x week) [ ] always (every night)
Q4 Do you need to rush or hurry to pass urine when you get the urge? [ ] never [ ] occasionally (< 1 x week) [ ] frequently (≥ 1 x week) [ ] daily	**Q5** Does urine leak when you rush or hurry to the toilet? Do you not make it in time? [ ] never [ ] occasionally (< 1 x week) [ ] frequently (≥ 1 x week) [ ] daily	**Q6** Do you leak with coughing, sneezing, laughing or exercising? [ ] never [ ] occasionally (< 1/week) [ ] frequently (≥ 1/week) [ ] daily
Q7 Is your urinary stream (urine flow) weak, prolonged or slow? [ ] never [ ] occasionally (< 1 x week) [ ] frequently (≥ 1 x week) [ ] daily	**Q8** Do you have a feeling of incomplete bladder emptying? [ ] never [ ] occasionally (< 1 x week) [ ] frequently (≥ 1 x week) [ ] daily	**Q9** Do you need to strain to empty your bladder? [ ] never [ ] occasionally (< 1 x week) [ ] frequently (≥ 1 x week) [ ] daily
Q10 Do you have to wear pads because of urinary leakage? [ ] none – never [ ] as a precaution [ ] with exercise/during a cold [ ] daily	**Q11** Do you limit your fluid intake to decrease urinary leakage? [ ] never [ ] before going out [ ] moderately [ ] always	**Q 12** Do you have frequent bladder infections? [ ] no [ ] 1 – 3 per year [ ] 4 – 12 per year [ ] > 1 per month
Q13 Do you have pain in your bladder or urethra when you empty your bladder? [ ] never [ ] occasionally (< 1/week) [ ] frequently (≥ 1/week) [ ] daily	**Q 14** Does urine leakage affect your routine activities (recreation, socializing, sleeping, shopping etc.)? [ ] not at all [ ] slightly [ ] moderately [ ] greatly	**Q 15** How much does your bladder problem bother you? [ ] not at all [ ] slightly [ ] moderately [ ] greatly

Bowel Section

Q 16 How often do you usually open your bowels? [ ] every other day or daily [ ] less than every 3 days [ ] less than once per week [ ] more than once a day	**Q 17** What is the consistency of your usual stool? [ ] soft [ ] firm [ ] hard (pebbles) [ ] watery [ ] variable	**Q 18** Do you have to strain a lot to empty your bowels? [ ] never [ ] occasionally (< 1 x week) [ ] frequently (≥ 1 x week) [ ] daily
Q 19 Do you use laxatives to empty your bowels? [ ] never [ ] occasionally (< 1 x week) [ ] frequently (≥ 1 x week) [ ] daily	**Q 20** Do you feel constipated? [ ] never [ ] occasionally (< 1 x week) [ ] frequently (≥ 1 x week) [ ] daily	**Q 21** When you get wind or flatus, can you control it or does wind leak? [ ] never [ ] occasionally (< 1 x week) [ ] frequently (≥ 1 x week) [ ] daily
Q 22 Do you get an overwhelming sense of urgency to empty your bowels? [ ] never [ ] occasionally (< 1 x week) [ ] frequently (≥ 1 x week) [ ] daily	**Q 23** Do you leak watery stool when you don't mean to? [ ] never [ ] occasionally (< 1 x week) [ ] frequently (≥ 1 x week) [ ] daily	**Q 24** Do you leak normal stool when you don't mean to? [ ] never [ ] occasionally (< 1 x week) [ ] frequently (≥ 1 x week) [ ] daily
Q 25 Do you have the feeling of incomplete bowel emptying? [ ] never	**Q 26** Do you have to use finger pressure to help empty your bowels?	**Q 27** How much does your bowel problem bother you? [ ] not at all

[ ] occasionally (< 1 x week) [ ] frequently (≥ 1 x week) [ ] daily	[ ] never [ ] occasionally (< 1 x week) [ ] frequently (≥ 1 x week) [ ] daily	[ ] slightly [ ] moderately [ ] greatly

Prolapse section

Q 28 Do you have a sensation of tissue protrusion or a lump or bulging in your vagina? [ ] never [ ] occasionally (< 1 x week) [ ] frequently (≥ 1 x week) [ ] daily	**Q 29** Do you experience vaginal pressure or heaviness or a dragging sensation? [ ] never [ ] occasionally (< 1 x week) [ ] frequently (≥ 1 x week) [ ] daily	**Q 30** Do you have to push your prolapse back in order to empty your bladder? [ ] never [ ] occasionally (< 1 x week) [ ] frequently (≥ 1 x week) [ ] daily
Q 31 Do you have to push your prolapse back to empty your bowels? [ ] never [ ] occasionally (< 1 x week) [ ] frequently (≥ 1 x week) [ ] daily	**Q 32** How much does your prolapse problem bother you? [ ] not at all [ ] slightly [ ] moderately [ ] greatly	

Sexual Function Section

Q 33 Are you sexually active? [ ] no [ ] < 1 x week [ ] ≥ 1 x week [ ] daily or most days If you are not sexually active, please answer Q34 and Q42 only.	**Q 34** If you are not sexually active, please tell us why: [ ] I do not have a partner [ ] I am not interested [ ] my partner is unable [ ] vaginal dryness [ ] too painful [ ] embarrassment due to bladder, bowel or prolapse [ ] other reasons:	**Q 35** Do you have sufficient natural vaginal lubrication during intercourse? [ ] yes [ ] no
Q 36 During intercourse vaginal sensation is: [ ] normal / pleasant [ ] minimal [ ] painful [ ] none	**Q 37** Do you feel that your vagina is too loose or lax? [ ] never [ ] occasionally [ ] frequently [ ] always	**Q 38** Do you feel that your vagina is too tight? [ ] never [ ] occasionally [ ] frequently [ ] always
Q 39 Do you experience pain with sexual intercourse? [ ] never [ ] occasionally [ ] frequently [ ] always	**Q 40** Where does the pain during intercourse occur? [ ] not applicable, I do not have pain [ ] at the entrance to the vagina [ ] deep inside, in the pelvis [ ] both at the entrance and in the pelvis	**Q 41** Do you leak urine during sexual intercourse? [ ] never [ ] occasionally [ ] frequently [ ] always
Q 42 How much do these sexual issues bother you? [ ] not applicable, I do not have a problem [ ] not at all [ ] slightly [ ] moderately [ ] greatly		

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Appendix 2

The Australian Pelvic Floor Questionnaire (Icelandic version)

Ástralski grindarbotnsspurningalistinn- Íslensk útgáfa

Spurningalistinn skiptist í 5 kafla. Merktu við það svar sem á best við um þig. Svaraðu í samræmi við einkenni þín síðast liðinn mánuð.

Þakka þér fyrir að taka þátt í könnuninni. Það skiptir miklu fyrir rannsóknina að öllum spurningum sé svarað.

Það eru 42 spurningar í þessari könnun

Blöðrustarfsemi

1 Hversu oft pissar þú yfir daginn?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Allt að 7 sinnum á dag

☐ 8-10 sinnum á dag

☐ 11-15 sinnum á dag

☐ Oftar en 15 sinnum á dag

☐ Vil ekki svara

2 Hversu oft pissar þú á nóttunni?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ 0 til einu sinni

☐ Tvisvar sinnum

☐ Þrisvar sinnum

☐ Oftar en þrisvar sinnum

☐ Vil ekki svara

3 Missir þú þvag áður en þú vaknar á nóttunni?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Aldrei

☐ Stöku sinnum (sjáldnar en einu sinni í viku)

☐ Oft (einu sinni í viku eða oftar)

☐ Alltaf (á hverri nóttu)

☐ Vil ekki svara

4 Þarftu að flýta þér á klósett þegar þér verður mál?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Get haldið í mér

☐ Þarf stundum að flýta mér (sjaldnar en einu sinni í viku)

☐ Þarf oft að flýta mér (einu sinni í viku eða oftar)

☐ Daglega

☐ Vil ekki svara

5 Missir þú þvag á leiðinni á klósett þegar þér er mikið mál?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Alls ekki

☐ Stöku sinnum (sjaldnar en einu sinni í viku)

☐ Oft (einu sinni í viku eða oftar)

☐ Daglega

☐ Vil ekki svara

6 Missir þú þvag þegar þú hóstar, hnerrar, hlærð eða reynir á þig?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Alls ekki

☐ Stöku sinnum (sjaldnar en einu sinni í viku)

☐ Oft (einu sinni í viku eða oftar)

☐ Daglega

☐ Vil ekki svara

7 Er þvagbunan (þvagflæðið) slöpp, langdregin eða hæg?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Aldrei

☐ Stöku sinnum (sjaldnar en einu sinni í viku)

☐ Oft (einu sinni í viku eða oftar)

☐ Daglega

☐ Vil ekki svara

8 Finnst þér blaðran tæmast illa (hefur þú þá tilfinningu að blaðran tæmist ekki nógu vel)?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Aldrei

☐ Stöku sinnum (sjaldnar en einu sinni í viku)

☐ Oft (einu sinni í viku eða oftar)

☐ Daglega

☐ Vil ekki svara

9 Þarftu að rembast til að tæma blöðruna?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Aldrei

☐ Stöku sinnum (sjaldnar en einu sinni í viku)

☐ Oft (einu sinni í viku eða oftar)

☐ Daglega

☐ Vil ekki svara

10 Þarftu að nota innlegg/bindi vegna þvagleka?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Engin-aldrei

☐ Til vonar og vara

☐ Þegar ég reyni á mig/þegar ég er kvefuð

☐ Daglega

☐ Vil ekki svara

11 Takmarkar þú vökvadrykkju til að minnka þvagleka?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

- [ ] Aldrei
- [ ] Áður en ég fer út
- [ ] All nokkuð
- [ ] Alltaf
- [ ] Vil ekki svara

12 Færðu oft þvagfærasýkingar (blöðrubólgu)?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

- [ ] Nei
- [ ] 1-3 á ári
- [ ] 4-12 á ári
- [ ] Fleiri en eina í mánuði
- [ ] Vil ekki svara

13 Færðu verk í blöðruna eða þvagrásina þegar þú pissar?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

- [ ] Aldrei
- [ ] Stöku sinnum (sjaldnar en einu sinni í viku)
- [ ] Oft (einu sinni í viku eða oftar)
- [ ] Daglega

☐ Vil ekki svara

14 Hefur þvagleki truflandi áhrif á venjubundnar athafnir, eins og afþreyingu, félagslíf, svefn, verslunarferðir og svo framvegis?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Alls ekki

☐ Lítillega

☐ Nokkuð

☐ Mikið

☐ Vil ekki svara

15 Hversu mikið angra blöðruvandamálin þig?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Ekkert

☐ Lítillega

☐ Nokkuð

☐ Mikið

☐ Vil ekki svara

Ristilstarfsemi

16 Hversu oft hefur þú hægðir?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Annan hvern dag eða daglega

☐ Sjaldnar en þriðja hvern dag

☐ Sjaldnar en vikulega

☐ Oftar en einu sinni á dag

☐ Vil ekki svara

17 Hvernig eru hægðirnar venjulega?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Mjúkar

☐ Þéttar

☐ Harðar (spörð)

☐ Þunnfljótandi

☐ Breytilegar

☐ Vil ekki svara

18 Þarftu að rembast mikið til að hafa hægðir?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Aldrei

☐ Stöku sinnum (sjaldnar en einu sinni í viku)

☐ Oft (einu sinni í viku eða oftar)

☐ Daglega

☐ Vil ekki svara

19 Notar þú hægðalyf?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Aldrei

☐ Stöku sinnum (sjaldnar en einu sinni í viku)

☐ Oft (einu sinni í viku eða oftar)

☐ Daglega

☐ Vil ekki svara

20 Finnur þú fyrir hægðatregðu?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Aldrei

☐ Stöku sinnum (sjaldnar en einu sinni í viku)

☐ Oft (einu sinni í viku eða oftar)

☐ Daglega

☐ Vil ekki svara

21 Leysir þú vind (prumpar) óviljandi?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Aldrei

☐ Stöku sinnum (sjaldnar en einu sinni í viku)

☐ Oft (einu sinni í viku eða oftar)

☐ Daglega

☐ Vil ekki svara

22 Færð þú bráða hægðaþörf?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Aldrei

☐ Stöku sinnum (sjaldnar en einu sinni í viku)

☐ Oft (einu sinni í viku eða oftar)

☐ Daglega

☐ Vil ekki svara

23 Missir þú þunnfljótandi hægðir óviljandi?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Aldrei

☐ Stöku sinnum (sjaldnar en einu sinni í viku)

☐ Oft (einu sinni í viku eða oftar)

☐ Daglega

☐ Vil ekki svara

24 Missir þú eðlilegar hægðir óviljandi?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Aldrei

☐ Stöku sinnum (sjaldnar en einu sinni í viku)

☐ Oft (einu sinni í viku eða oftar)

☐ Daglega

☐ Vil ekki svara

25 Finnst þér hægðalosun ófullnægjandi-eins og þú náir ekki að klára?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Aldrei

☐ Stöku sinnum (sjaldnar en einu sinni í viku)

☐ Oft (einu sinni í viku eða oftar)

☐ Daglega

☐ Vil ekki svara

26 Þarft þú að þrýsta með fingri til að auðvelda hægðalosun?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Aldrei

☐ Stöku sinnum (sjaldnar en einu sinni í viku)

☐ Oft (einu sinni í viku eða oftar)

☐ Daglega

☐ Vil ekki svara

27 Hve mikið angra ristil/hægðavandamál þig?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Ekkert

☐ Lítillega

☐ Nokkuð

☐ Mikið

☐ Vil ekki svara

Einkenni um sig í grindarholi

28 Finnur þú fyrir útbungun eða fyrirferð í leggöngum?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Aldrei

☐ Stöku sinnum (sjaldnar en einu sinni í viku)

☐ Oft (einu sinni í viku eða oftar)

☐ Daglega

☐ Vil ekki svara

29 Upplifir þú þrýsting eða þyngslatilfinningu í leggöngum?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Aldrei

☐ Stöku sinnum (sjaldnar en einu sinni í viku)

☐ Oft (einu sinni í viku eða oftar)

☐ Daglega

☐ Vil ekki svara

30 Þarftu að ýta fyrirferðinni/siginu til baka til að geta tæmt blöðruna?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Aldrei

☐ Stöku sinnum (sjaldnar en einu sinni í viku)

☐ Oft (einu sinni í viku eða oftar)

☐ Daglega

☐ Vil ekki svara

31 Þarftu að ýta fyrirferðinni/siginu til baka til að geta haft hægðir?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Aldrei

☐ Stöku sinnum (sjaldnar en einu sinni í viku)

☐ Oft (einu sinni í viku eða oftar)

☐ Daglega

☐ Vil ekki svara

32 Hve mikið angra sig-vandamálin þig?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Ekkert

☐ Lítillega

☐ Nokkuð

☐ Mikið

☐ Vil ekki svara

Kynlíf

33 Stundar þú kynlíf?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Nei

☐ Sjaldnar en einu sinni í viku

☐ Einu sinni í viku eða oftar

☐ Daglega eða flesta daga

☐ Vil ekki svara

Ef þú stundar ekki kynlíf (svarar nei) vinsamlegast svaraðu bara spurningum 34 og 42.

34 Ef þú stundar ekki kynlíf, viltu tilgreina ástæðuna?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Á ekki félaga/maka

☐ Hef ekki áhuga

☐ Félagi/maki ófær um kynlíf

☐ Þurrkur í leggöngum

☐ Of sársaukafullt

☐ Feimni/skömm vegna sigs eða leka

☐ Aðrar ástæður. Viltu tilgreina hvaða ástæður? Vinsamlegast skrifaðu svar þitt hér:

_____

☐ Vil ekki svara

35 Hefur þú nægilegan náttúrulegan raka í leggöngum við samfarir?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

- [ ] Já
- [ ] Nei
- [ ] Vil ekki svara

36 Við samfarir er tilfinning í leggöngum:

Vinsamlegast veldu aðeins eitt af eftirfarandi:

- [ ] Eðlileg/þægileg
- [ ] Lítil
- [ ] Sársaukafull
- [ ] Engin
- [ ] Vil ekki svara

37 Finnst þér leggöngin víð eða slöpp?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

- [ ] Aldrei
- [ ] Stöku sinnum
- [ ] Oft
- [ ] Alltaf
- [ ] Vil ekki svara

38 Finnst þér leggöngin of þröng?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

- [ ] Aldrei
- [ ] Stöku sinnum
- [ ] Oft
- [ ] Alltaf
- [ ] Vil ekki svara

39 Finnur þú fyrir sársauka við samfarir?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

- [ ] Aldrei
- [ ] Stöku sinnum
- [ ] Oft
- [ ] Alltaf
- [ ] Vil ekki svara

40 Hvar finnur þú fyrir sársauka við samfarir?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

- [ ] Á ekki við, finn ekki sársauka
- [ ] Við leggangaopið
- [ ] Djúpt í grindarholi

☐ Bæði við leggangaopið og djúpt í grindarholi

☐ Vil ekki svara

41 Missir þú þvag við samfarir?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Aldrei

☐ Stöku sinnum

☐ Oft

☐ Alltaf

☐ Vil ekki svara

42 Hversu mikið angra þessi kynlífstengdu atriði þig?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Á ekki við, hef ekki vandamál

☐ Ekkert

☐ Lítillega

☐ Nokkuð

☐ Mikið

☐ Vil ekki svara

Appendix 3

Exercise diary for recording of home exercises (English version)

Postpartum pelvic floor symptoms and early intervention with physical therapy: A PhD study

An exercise diary for pelvic floor muscle exercises to do at home

Name and number of the participant:

Breastfeeding at the beginning of participation (put a ring around the right answer): Yes No

Week	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Date/PT
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								

Breastfeeding stopped: (if applicable): _____ week postpartum

Appendix 4

Exercise diary for recording of home exercises (Icelandic version)

Grindarbotnseinkenni og snemmíhlutun með sjúkraþjálfun:
Doktorsrannsókn
Ástundunarblað fyrir grindarbotnsæfingar heima

Nafn og númer þátttakanda:_____

Brjóstagjöf við upphaf þátttöku (setjið hring utan um svar): Já Nei Brjóstagjöf hætt (ef við á): _____ viku

Vika	Mánud.	Þriðjud.	Miðvikud.	Fimmtud.	Föstud.	Laugard.	Sunnud.	Dags./mætt
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								

Appendix 5

Questionnaire about pelvic floor muscle training (English version)

Pelvic floor muscle exercises the first year after childbirth

A short survey about how you did pelvic floor muscle exercises the first year after childbirth.
I want you to give me further information on how you did pelvic floor muscle exercises the first year after childbirth. It will help a lot with the processing of the data.

There are 7 questions in this survey

The first half of the year after childbirth.

1 Which group did you belong to? Intervention group (meetings with a physical therapist) or the control group (no meetings with a physical therapist).

Please choose **only one** of the following:

○ I was in the intervention group and met with a physical therapist during the first half of the year after the childbirth.

○ I was in the control group and therefore had no meetings with a physical therapist.

You choose intervention group if you had any meetings with a physical therapist even if you did not finish the program.

Questions 2, 3 og 4 apply only to women in the control group:

2 Did you do pelvic floor muscle exercises during the first half of the year after childbirth:

Please choose **only one** of the following:

○ No.

○ Yes, daily.

○ Yes, at least three times a week.

○ Yes, once or twice a week.

◯ Yes, at least once a week.

◯ Yes, sometimes when I felt I needed it.

3 How many exercises each day did you do on avarage when you did exercise?*

Please write your answer here: _____

* This means the whole number of contractions you did. If you did 10 contractions and repeated this for example three times, please write 30.

4 For how long on average did you hold each contraction?*

Please write your answer here:

* Please write the number in seconds: _____

The latter half of the year after childbirth.

5 Did you do pelvic floor muscle exercises during the latter half of the year after childbirth?

Please choose **only one** of the following:

◯ No.

◯ Yes, daily.

◯ Yes, at least three times a week.

◯ Yes, once or twice a week.

◯ Yes, at least once a week.

◯ Yes, sometimes when I felt I needed it.

6 How many exercises each day did you do on avarage when you did exercise?*

Please write your answer here: _____

* This means the whole number of contractions you did. If you did 10 contractions and repeated this for example three times, please write 30.

7 For how long on average did you hold each contraction?*

Please write your answer here : _____

* Please write the number in seconds.

Thank you for completing this survey.

Appendix 6

Questionnaire about pelvic floor muscle training (Icelandic version)

Grindarbotnsæfingar fyrsta árið eftir fæðingu

Örstutt könnun á því hvernig þú gerðir grindarbotnsæfingar fyrsta árið eftir fæðingu.
Mig langar til að fá hjá þér frekari upplýsingar um iðkun grindarbotnsæfinga árið eftir fyrstu fæðingu. Það hjálpar mikið við úrvinnslu niðurstaðna.

Það eru 7 spurningar í þessari könnun

Fyrsta hálfa árið eftir fæðingu.

1 Hvorum hópnum tilheyrðir þú? Meðferðarhóp (mætti til sjúkraþjálfara) eða samanburðarhóp (sem mætti ekki til sjúkraþjálfara).

Veldu **aðeins eitt svar**:

- ○ Ég var í meðferðarhópnum og mætti til sjúkraþjálfara í meðferð hluta af fyrsta hálfa árinu.
- ○ Ég var í samanburðarhópnum og mætti því ekki til sjúkraþjálfara fyrsta hálfa árið.

Þú merkir við meðferðarhóp ef þú komst í einhverja meðferðartíma þótt þú hafir ekki endilega klárað prógrammið.

Spurning 2, 3 og 4 eiga aðeins við þær sem voru í samanburðarhóp:

2 Gerðir þú grindarbotnsæfingar fyrsta hálfa árið eftir fæðingu?

Veldu **aðeins eitt** svar:

- ○ Nei.
- ○ Já, daglega.
- ○ Já, að minnsta kosti þrisvar í viku.
- ○ Já, einu sinni til tvisvar í viku.
- ○ Já, að minnsta kosti einu sinni í viku.
- ○ Já, stundum þegar mér fannst ég þurfa þess.

3 Hve margar æfingar gerðir þú að jafnaði á dag þegar þú gerðir grindarbotnsæfingar? *

Vinsamlegast skrifaðu svar þitt hér: _____

* Þarna er átt við fjölda samdrátta sem gerðir eru. Ef þú gerðir 10 samdrætti og endurtókst t.d. þrisvar sinnum skaltu rita 30.

4 Hve lengi hélstu hverjum vöðvasamdrætti að jafnaði þegar þú gerðir grindarbotnsæfingar? *

Vinsamlegast skrifaðu svar þitt hér: _____

* Ritaðu fjölda í sekúndum.

Seinna hálfa árið eftir fæðingu.

5 Gerðir þú grindarbotnsæfingar seinna hálfa árið eftir fæðingu?

Veldu **aðeins eitt** svar:

- ○ Nei.
- ○ Já, daglega.
- ○ Já, að minnsta kosti þrisvar í viku.
- ○ Já, einu sinni til tvisvar í viku.
- ○ Já, að minnsta kosti einu sinni í viku.
- ○ Já, stundum þegar mér fannst ég þurfa þess.

6 Hve margar æfingar gerðir þú að jafnaði á dag þegar þú gerðir grindarbotnsæfingar? *

Vinsamlegast skrifaðu svar þitt hér: _____

* Þarna er átt við fjölda samdrátta sem gerðir eru. Ef þú gerðir 10 samdrætti og endurtókst t.d. þrisvar sinnum skaltu rita 30.

7 Hve lengi hélstu hverjum vöðvasamdrætti að jafnaði þegar þú gerðir grindarbotnsæfingar? *

Vinsamlegast skrifaðu svar þitt hér: _____

* Ritaðu fjölda í sekúndum.

Kærar þakkir fyrir hjálpina. Hún er mikils virði.

Appendix 7

Questionnaire about physical activity and sports before and during first pregnancy (English version)

A survey about childbirth outcomes for elite athletes and a control group of non-athletic women

Dear participant. Thank you for participating in this study and for sharing information about sports, general physical activity and your first birth. We would like to ask you to try and remember as much as you can about how much you practiced / exercised on average. We know it can be difficult, especially if some time has passed since you had your first child.

The first questions are about background information used to identify the birth record such as mother´s ID number and the date of birth of your first child. Information on education, job and smoking are used for demographic analysis. Other questions are related to physical activity.

No personally identifiable information will ever be disclosed, nor will it be possible to trace responses to individual participants.

Background questions

Initial questions are related to background information, such as the ID number of the mother and date of birth to locate the birth record, employment status information and smoking for demographic analysis.

Read the questions carefully, it is important to get accurate responses.

ID number

Please write your answer here: (write without a hyphen, example: 2602872499) _____

Date of birth of your first child

Please write a date: (ddmmyy) _____

Level of education at the beginning of the first pregnancy

Please select only one of the following:

☐ Primary school education

☐ Secondary school education or equivalent

☐ University/college education or equivalent

Employment status before the first pregnancy

Please select only one of the following:

☐ In a paid job

☐ Homemaker

☐ In a sick leave

☐ Student

☐ Unemployed

☐ Other

Did you smoke before your first pregnancy?

Please select one of the following

☐ No never

☐ Yes but I quit. How many years before the first pregnancy did you quit? ____

☐ Yes. For how many years before your first pregnancy did you smoke? ____

Did you smoke during your first pregnancy?

Please select only one of the following:

☐ No never

☐ Yes, but I quit. During which month of pregnancy did you quit? _____

☐ Yes, during the whole pregnancy

Physical activity BEFORE the first pregnancy

The next questions are about physical activity before the first pregnancy. Questions about physical activity during the first pregnancy are presented in the next section.

Read the questions carefully, it is important to get accurate responses.

Did you participate in competitive sport at least 3 years before your first pregnancy?

Please select only one of the following:

☐ No

☐ Yes

If yes, what is/was your main competitive sport? How many hours a week on average did you practice (at least 3 years before your first pregnancy)?

Please select only one of the following:

☐ Team gymnastics. Hours a week? ____

☐ Artistic gymnastics. Hours a week? ____

☐ Football (soccer). Hours a week? ____

☐ Handball. Hours a week? ____

☐ Basketball. Hours a week? ____

☐ Volleyball. Hours a week? ____

☐ Track and field. Main sport in track and field? _____ Hours a week? ____

☐ Weightlifting. Hours a week? ____

☐ CrossFit/Boot camp. Hours a week? ____

☐ Racket sports (table tennis/tennis/badminton/squash). Hours a week? ____

☐ Riding (jockey). Hours a week? ____

☐ Dancing. Type of dance? _____ Hours a week? ____

☐ Golf. Hours a week? ____

☐ Self-defence sports (judo, karate, other). Hours a week? ____

☐ Swimming. Hours a week? ____

☐ Ice-skating. Hours a week? ____

☐ Skiing. Hours a week? ____

☐ Other. What sport? _____ Hours a week? ____

How many years before the first pregnancy did you practice/compete in the highest division / top class possible in your field of sport?

Please write your answer here: ____years

Did you compete with a national team (or equivalent) in your field of sport the years before your first pregnancy? Equivalent means your team or you as an individual represented on behalf of Iceland at international tournaments and competitions.

☐ No

☐ Yes. For how many years? ____

How long time passed from being active in the highest division/top class possible/national team in your competitive sport until your first pregnancy began? (if you were fully active until pregnancy then enter 00/00)

Please write your answer here: __/__

Mark here the number of months / years in the form mm / yy. Example: if you were active until 2 months before pregnancy, enter 02/00. If you quit all exercises / competitions 2 years before pregnancy then enter 00/02

Did you practice (other) targeted training for at least 3 years before your first pregnancy? This question refers only to targeted training (later questions will address general physical activity, such as walking, etc.)

Please select only one of the following:

☐ No

☐ Yes

"Other" if you were in competitive sports and trained something extra. If you were not an athlete in competitive sports, here we are asking if you, however, participated in targeted training.

If yes, what type of targeted training did you participate in before the first pregnancy? How many hours a week?

Please select all that applies:

☐ Strength training/exercises with weights. Hours a week? ____

☐ Endurance training like walking/jogging/running/treadmill. Hours a week? ____

☐ Flexibility training. Hours a week? ____

☐ Swimming. Hours a week? ____

☐ Other, what? (for instance, you can name a sport you practiced even though you did not compete in it) _____ Hours a week? ____

If yes, for how many years before the first pregnancy did you practice targeted training? Reply based on the training you practiced the most.

Please write your answer here: ____ years

How long time passed from active participation in targeted training until your first pregnancy began? (if you were fully active until pregnancy then enter 00/00)

Please write your answer here: __/__

Write here the number of months/years in the form mm/yy. Example: if you were active until 2 months before pregnancy, enter 02/00. If you quit all exercises/competitions 2 years before pregnancy then enter 00/02

Did you do pelvic floor muscle exercises for at least 6 months before the first pregnancy? (exercises for the muscles around the urethra, vagina and anus)

Please select only one of the following:

☐ No

☐ I can´t remember

☐ Yes, every day

☐ Yes, at least three times a week

☐ Yes, once or twice a week

☐ Yes, less than once a week

☐ Yes, sometimes, when I felt I needed it

How many contractions/exercises did you usually do a day when you did pelvic floor muscle exercises?

Please write your answer here: ____

How many seconds did you usually hold each contraction of the pelvic floor muscles when you exercised?

Please write your answer here: ____ seconds

Where did you learn / hear about pelvic floor muscle exercises?

Please select all that applies:

☐ In women´s magazines

☐ From other media, for ex. television, newspapers, the internet or similar

☐ From a physician

☐ From a physical therapist

☐ From a midwife

☐ From other health care providers

☐ In the gym

☐ From friends and relatives (for ex. mother, sister etc.)

☐ By participating in this study

☐ In a school. What kind of school? _____ (example: primary school, secondary school, university)

☐ By other means. How? _____

Were you physically active in general for at least 3 years before the first pregnancy? (this is a general daily activity which may involve walking and cycling to and from work and does NOT involve competition)

Please select only one of the following:

☐ No

☐ Yes, but not regularly

☐ Yes, regularly

General physical activity is the activity that is not categorized as competitive sports or other targeted training. Be careful not to repeat what you have already reported.

If yes, mark the type of physical activity and how much you usually did for at least 3 years before the first pregnancy.

Please select all that applies:

☐ Slow walking. How many hours a week on average? _____

☐ Brisk walking. How many hours a week on average? _____

☐ Jogging/running. How many hours a week on average? _____

☐ Varied exercises with an instructor/aerobic. How many hours a week on average? _____

☐ Training with weights. How many hours a week on average? _____

☐ Dance. Type of dance? _____ How many hours a week on average? _____

☐ Swimming. How many hours a week on average? _____

☐ Bycycling. How many hours a week on average? _____

☐ Other, what? _____ How many hours a week on average? _____

Were you physically active right until your pregnancy began? (if you were fully active until pregnancy, write 00/00) Based on what you last stopped doing.

Please write your answer here: __/__

Mark here the number of months / years in the form mm / yy. Example: if you were active until 2 months before pregnancy, enter 02/00. If you quit more and less of the general physical activity 2 years before pregnancy then enter 00/02

Physical activity DURING first pregnancy

The following questions are only about your first pregnancy and physical activity during it.
Read the questions carefully because it is very important that the answers are accurate.

If you were a competitive athlete and were active in your main sport, mark how much you normally exercised/trained. Do not include normal holidays or other training. Another question will be raised about other training. If you were a competitive athlete but did not practice any of your sports during pregnancy, enter 0 in the box that appears.

Please select only either one of the following:

☐ I am not a competitive athlete

☐ I am a competitive athlete

Questions about other targeted training are provided below.

How many hours a week did you usually practice your sport during your first pregnancy?

Please write your answer here: _____

Enter the number of hours

If you were active in your competitive sport during your first pregnancy, when did you stop exercising/competing?

Please write your answer here: ____

Example: If you practiced until month 4, type 4. If you practiced the whole pregnancy, type 9. If you do not exercise during the pregnancy, enter 0

Did you practice (other) targeted training during your first pregnancy? This question refers only to targeted training (later, questions about physical activity will be asked, such as walking, etc.)

Please select only either one of the following:

☐ No

☐ Yes

"Other" means if you were in competitive sports and practiced something extra. If you weren't into competitive sports, here's asking if you however, participated in targeted training.

If yes, what type of targeted training did you do during your first pregnancy?

Please select all that applies:

☐ Strength training/exercises with weights. How many hours a week on average? _____

☐ Endurance training like walking/jogging/running/treadmill. How many hours a week on average? _____

☐ Flexibility training. How many hours a week on average? _____

☐ Swimming. How many hours a week on average? _____

☐ Other, what? _____ For instance, you can name a sport you practiced even though you did not compete in it. How many hours a week on average? _____

If you were into other targeted training during the first pregnancy, what month of pregnancy would you discontinue? (answer based on what you last stopped training)

Please write your answer here: ____

Example: If you trained until month 4, type 4. If you trained the whole pregnancy, enter 9.

Did you do pelvic floor muscle exercises during your first pregnancy? (exercises for the muscles around the urethra, vagina and anus)

Please select only one of the following:

☐ No

☐ I can´t remember

☐ Yes, every day

☐ Yes, at least three times a week

☐ Yes, once or twice a week

☐ Yes, less than once a week

☐ Yes, sometimes, when I felt I needed it

How many contractions / exercises did you usually do a day when you did pelvic floor muscle exercises?

Please write your answer here: ____

How many seconds did you usually hold each contraction of the pelvic floor muscles when you exercised?

Please write your answer here: ____ seconds

Were you physically active in general during your first pregnancy? (this means general daily activities that can include walking and cycling to and from work and generally does NOT involve competition)

Please select only one of the following:

☐ No

☐ Yes, but not regularly

☐ Yes, regularly

General physical activity is the activity that is not categorized as competitive sports or other targeted training. Be careful not to repeat what has already been reported.

Mark the type of training and how much you did during the first pregnancy

Please select all that applies:

☐ Slow walking. How many hours a week on average? _____

☐ Brisk walking. How many hours a week on average? _____

☐ Jogging/running. How many hours a week on average? _____

☐ Varied exercises with an instructor/aerobic. How many hours a week on average? _____

☐ Training with weights. How many hours a week on average? _____

☐ Dance. Type of dance? _____ How many hours a week on average? _____

☐ Swimming. How many hours a week on average? _____

☐ Bycycling. How many hours a week on average? _____

☐ Other, what? _____ How many hours a week on average? _____

If you were generally physically active during your first pregnancy, what month of pregnancy did you discontinue your general physical activity? Answer according to the activity you stopped doing the last.

Please write your answer here: ____

Example: If you were active until the 4th month of pregnancy, enter 4. If you were generally physically active throughout pregnancy, write 9.

Thank you very much for participating in this study.

Appendix 8

Questionnaire about physical activity and sports before and during first pregnancy (Icelandic version)

Könnun á fæðingarútkomu afreksíþróttakvenna og samanburðarhóps

Kæri þátttakandi. Þakka þér fyrir að taka þátt í þessari rannsókn og fyrir að deila upplýsingum um íþróttaiðkun, almenna hreyfingu og fyrstu fæðingu þína. Við viljum biðja þig um að reyna að muna eins vel og þú getur hversu mikið þú æfðir/hreyfðir þig að jafnaði. Við vitum að það getur reynst erfitt, sérstaklega ef einhver tími er liðinn síðan þú áttir þitt fyrsta barn.

Fyrstu spurningar eru um grunnupplýsingar sem notaðar eru til úrvinnslu eins og t.d. kennitala móður og fæðingardagur barns svo hægt sé að finna fæðingarskýrslu, menntun, starf og reykingar vegna lýðfræðilegra athugana. Aðrar spurningar eru tengdar líkamlegri virkni.

Engar persónugreinanlegar upplýsingar munu nokkurn tíma koma fram né verður hægt að rekja svör til einstakra þátttakenda.

Bakgrunnsspurningar

Fyrstu spurningar lúta að bakgrunnsupplýsingum, eins og kennitölu móður og fæðingardegi barns til að hægt sé að finna fæðingarskrá, upplýsingar um stöðu og reykingar eru lýðfræðilegar upplýsingar sem verða nýttar við úrvinnslu.

Lesið spurningarnar vel því miklu skiptir að svör séu sem nákvæmust.

Kennitala

Vinsamlegast skrifaðu svar þitt hér: (skráið inn án bandstriks, dæmi: 2602872499) _____

Fæðingardagur fyrsta barns

Vinsamlegast settu inn dagsetningu: (ddmmáá) _____

Menntunarstig við upphaf fyrstu meðgöngu.

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Grunnskólamenntun

☐ Framhaldsskólamenntun eða sambærilegt

☐ Háskólamenntun eða sambærilegt

Staða fyrir fyrstu meðgöngu

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Í launuðu starfi

☐ Heimavinnandi

☐ Í sjúkraleyfi

☐ Námsmaður

☐ Atvinnulaus

☐ Annað

Reyktir þú fyrir fyrstu meðgöngu þína?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Nei, aldrei

☐ Já, en ég hætti. Hve mörgum árum fyrir fyrstu meðgöngu hættir þú að reykja? ____

☐ Já. Í hversu mörg ár reyktir þú fyrir fyrstu meðgöngu? ____

Reyktir þú á fyrstu meðgöngu?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Nei, aldrei

☐ Já, en ég hætti. Á hvaða mánuði meðgöngu hættir þú að reykja? ____

☐ Já, alla meðgönguna

Líkamleg virkni FYRIR fyrstu meðgöngu

Næstu spurningar eru um líkamlega virkni fyrir fyrstu meðgöngu. Sérstaklega verður spurt um líkamlega virkni á fyrstu meðgöngu í næsta kafla á eftir.

Lesið spurningarnar vel því miklu skiptir að svör séu sem nákvæmust.

Iðkaðir þú keppnisíþrótt í að minnsta kosti 3 ár fyrir fyrstu meðgöngu?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Nei

☐ Já

Ef já, hver er/var þín aðal keppnisíþrótt? Í hversu margar klukkustundir á viku æfðir þú að jafnaði (að minnsta kosti í 3 ár fyrir fyrstu meðgöngu)?

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Hópfimleikar. Klukkustundir á viku? ____

☐ Áhaldafimleikar. Klukkustundir á viku? ____

☐ Knattspyrna. Klukkustundir á viku? ____

☐ Handknattleikur. Klukkustundir á viku? ____

☐ Körfuknattleikur. Klukkustundir á viku? ____

☐ Blak. Klukkustundir á viku? ____

☐ Frjálsar íþróttir. Aðalgrein innan frjálsra? _____ Klukkustundir á viku? ____

☐ Lyftingar. Klukkustundir á viku? ____

☐ CrossFit/Boot camp. Klukkustundir á viku? ____

☐ Spaðaíþróttir (borðtennis/tennis/badminton/skvass). Klukkustundir á viku? ____

☐ Reiðmennska (knapi). Klukkustundir á viku? ____

☐ Dans. Hvernig dans? _____ Klukkustundir á viku? ____

☐ Golf. Klukkustundir á viku? ____

☐ Júdó/karate/aðrar sjálfsvarnaríþróttir. Klukkustundir á viku? ____

☐ Sund. Klukkustundir á viku? ____

☐ Skautaíþróttir. Klukkustundir á viku? ____

☐ Skíðaíþróttir. Klukkustundir á viku? ____

☐ Annað. Hvaða íþróttagrein? _____ Klukkustundir á viku? ____

Hversu mörg ár fyrir fyrstu meðgöngu æfðir/kepptir þú í efstu deild/efsta flokki mögulegum í þinni íþróttagrein?

Vinsamlegast skrifaðu svar þitt hér: ____ ár

Kepptir þú með landsliði (eða sambærilegu) í þinni íþróttagrein árin fyrir fyrstu meðgöngu? Með sambærilegu er átt við ef íþróttafélagið þitt eða þú sem einstaklingur varst fulltrúi á alþjóðlegum mótum og kepptir fyrir hönd Íslands.

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Nei

☐ Já. Í hve mörg ár? ____

Hvað leið langur tími frá því að þú varst virk í efstu deild/efsta flokki mögulegum/landsliði í þinni keppnisíþrótt þangað til þín fyrsta meðganga hófst? (ef þú varst virk alveg fram að meðgöngu ritaðu þá 00/00)

Vinsamlegast skrifaðu svar þitt hér: __/__

Merktu hér við fjölda mánaða/ára á forminu mm/áá. Dæmi: ef þú varst virk þar til 2 mánuðum fyrir meðgöngu ritaðu þá 02/00. Ef þú hættir öllum æfingum/keppni 2 árum fyrir meðgöngu ritaðu þá 00/02

Stundaðir þú (aðra) markvissa þjálfun í að minnsta kosti 3 ár fyrir fyrstu meðgöngu? Í þessari spurningu er aðeins átt við markvissa þjálfun (síðar verður spurt um aðra líkamlega virkni eins og gönguferðir o.s.frv.)

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Nei

☐ Já

"Aðra" ef þú varst í keppnisíþróttum og æfðir eitthvað til viðbótar. Ef þú varst ekki í keppnisíþrótt er hér verið að spyrja um hvort þú hafir samt sem áður verið í markvissri þjálfun.

Ef já, hvaða tegund markvissrar þjálfunar stundaðir þú fyrir fyrstu meðgöngu? Hversu margar klukkustundir á viku?

Vinsamlegast veldu allt sem við á:

☐ Styrktarþjálfun/þjálfun með þyngdum. Klukkustundir á viku? ____

☐ Úthaldsþjálfun eins og ganga/skokk/hlaup/hlaupabretti. Klukkustundir á viku? ____

☐ Liðleikaþjálfun. Klukkustundir á viku? ____

☐ Sund. Klukkustundir á viku? ____

☐ Annað, Hvað? (hér má til dæmis nefna íþróttagrein sem þú æfðir þó þú hafir ekki keppt í henni) _____ Klukkustundir á viku? ____

Ef já, í hversu mörg ár fyrir fyrstu meðgöngu stundaðir þú markvissa þjálfun? Svaraðu út frá þeirri grein sem þú stundaðir mest.

Vinsamlegast skrifaðu svar þitt hér: ____ ár

Hvað leið langur tími frá því þú varst virk í markvissri þjálfun þangað til þín fyrsta meðganga hófst? (ef þú varst virk alveg fram að meðgöngu ritaðu þá 00/00)

Vinsamlegast skrifaðu svar þitt hér:

Merktu hér við fjölda mánaða/ára á forminu mm/áá. Dæmi: ef þú varst virk þar til 2 mánuðum fyrir meðgöngu ritaðu þá 02/00. Ef þú hættir öllum æfingum/keppni 2 árum fyrir meðgöngu ritaðu þá 00/02

Gerðir þú grindarbotnsæfingar í að minnsta kosti 6 mánuði fyrir fyrstu meðgöngu? (æfingar fyrir vöðvana í kring um þvagrás, leggöng og endaþarm)

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Nei

☐ Ég man það ekki

☐ Já, daglega

☐ Já, að minnsta kosti þrisvar í viku

☐ Já, einu sinni til tvisvar í viku

☐ Já, einu sinni í viku eða sjaldnar

☐ Já, stundum, þegar mér fannst ég þurfa þess

Hvað marga samdrætti/æfingar gerir þú að jafnaði á dag þegar þú gerðir grindarbotnsæfingar?

Vinsamlegast skrifaðu svar þitt hér: ____

Hvað hélstu hverjum samdrætti í margar sekúndur að jafnaði þegar þú gerðir grindarbotnsæfingar?

Vinsamlegast skrifaðu svar þitt hér: ____sekúndur

Hvar lærðir þú/heyrðir um grindarbotnsæfingar?

Vinsamlegast veldu allt sem við á:

☐ Í kvennatímaritum

☐ Í öðrum fjölmiðlum, t.d. sjónvarpi, dagblöðum, af netinu og þess háttar

☐ Hjá lækni

☐ Hjá sjúkraþjálfara

☐ Hjá ljósmóður

☐ Hjá öðru heilbrigðisstarfsfólki

☐ Í líkamsrækt

☐ Hjá vinum og ættingjum (t.d. móður, systur o.fl.)

☐ Með þátttöku í þessari rannsókn

☐ Í skóla. Hvernig skóla? _____ (dæmi: grunnskóla, framhaldsskóla, háskóla)

☐ Á annan hátt. Hvernig? _____

Varstu almennt séð líkamlega virk í að minnsta kosti 3 ár fyrir fyrstu meðgöngu? (hér er verið að ræða um almenna daglega virkni sem getur falið í sér að ganga og hjóla til og frá vinnu og felur almennt séð EKKI í sér keppni)

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Nei

☐ Já, en ekki reglulega

☐ Já, reglulega

Almenn líkamleg virkni er sú hreyfing sem hvorki flokkast undir keppnisíþróttir né aðra markvissa þjálfun. Gætið að því að endurtaka ekki það sem búið var að greina frá.

Ef já, merktu við tegund þjálfunar og hvað þú hreyfðir þig mikið að jafnaði í að minnsta kosti 3 ár fyrir fyrstu meðgöngu

Vinsamlegast veldu allt sem við á:

☐ Hæg ganga. Hversu margar klukkustundir í viku að jafnaði? ____

☐ Hröð ganga. Hversu margar klukkustundir í viku að jafnaði? ____

☐ Skokk/hlaup. Hversu margar klukkustundir í viku að jafnaði? ____

☐ FJölbreytt leikfimi með kennara/eróbikk. Hversu margar klukkustundir í viku að jafnaði? ____

☐ Tækjaþjálfun í sal. Hversu margar klukkustundir í viku að jafnaði? ____

☐ Dans. Hvernig dans? _____Hversu margar klukkustundir í viku að jafnaði? ____

☐ Sund. Hversu margar klukkustundir í viku að jafnaði? ____

☐ Hjólreiðar. Hversu margar klukkustundir í viku að jafnaði? ____

☐ Annað, hvað? _____ Hversu margar klukkustundir í viku að jafnaði? ____

Hvað leið langur tími frá því þú varst almennt líkamlega virk þangað til þín fyrsta meðganga hófst? (ef þú varst virk alveg fram að meðgöngu ritaðu þá 00/00) Miðaðu við það sem þú hættir síðast að stunda.

Vinsamlegast skrifaðu svar þitt hér: ____

Merktu hér við fjölda mánaða/ára á forminu mm/áá. Dæmi: ef þú varst virk þar til 2 mánuðum fyrir meðgöngu ritaðu þá 02/00. Ef þú hættir meira og minna allri almennri hreyfingu 2 árum fyrir meðgöngu ritaðu þá 00/02

Líkamleg virkni Á fyrstu meðgöngu

Næstu spurningar eru eingöngu um fyrstu meðgöngu þína og líkamlega virkni á meðan á henni stóð.

Lesið spurningarnar vel því miklu skiptir að svör séu sem nákvæmust.

Ef þú varst keppnisíþróttakona og varst virk í þinni keppnisíþrótt á fyrstu meðgöngu merktu við hvað mikið þú æfðir að jafnaði. Ekki taka með í reikningana eðlileg frí né aðra þjálfun. Spurt verður sérstaklega um það í sér spurningu. Ef þú varst keppnisíþróttakona en æfðir ekki neitt þína íþrótt á meðgöngu ritaðu þá 0 í reitinn sem birtist.

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Ég er ekki keppnisíþróttakona

☐ Ég er keppnisíþróttakona

Spurningar um aðra markvissa þjálfun koma hér á eftir.

Hve margar klukkustundir í viku æfðir þú að jafnaði þína keppnisíþrótt á fyrstu meðgöngu?

Vinsamlegast skrifaðu svar þitt hér: ____

Ritaðu fjölda klukkustunda í heilum tölum

Ef þú varst virk í þinni keppnisíþrótt á fyrstu meðgöngu, hvenær hættir þú æfingum/keppni?

Vinsamlegast skrifaðu svar þitt hér: ____

Dæmi: Ef þú æfðir fram á 4. mánuð ritaðu þá 4 í reitinn. Ef þú æfðir alla meðgönguna ritaðu á 9 í reitinn. Ef þú æfir ekki á meðgöngu ritaðu 0

Stundaðir þú (aðra) markvissa þjálfun á fyrstu meðgöngu? Í þessari spurningu er aðeins átt við markvissa þjálfun (síðar verður spurt um aðra líkamlega virkni eins og gönguferðir o.s.frv.)

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Já

☐ Nei

"Aðra" ef þú varst í keppnisíþróttum og æfðir eitthvað til viðbótar. Ef þú varst ekki í keppnisíþrótt er hér verið að spyrja um hvort þú hafir samt sem áður verið í markvissri þjálfun.

Ef já, hvaða tegund markvissrar þjálfunar stundaðir þú á fyrstu meðgöngu?

Vinsamlegast veldu allt sem við á:

☐ Styrktarþjálfun/þjálfun með þyngdum. Hversu margar klukkustundir í viku að jafnaði? ____

☐ Úthaldsþjálfun eins og ganga/skokk/hlaup/hlaupabretti. Hversu margar klukkustundir í viku að jafnaði? ____

☐ Liðleikaþjálfun. Hversu margar klukkustundir í viku að jafnaði? ____

☐ Sund. Hversu margar klukkustundir í viku að jafnaði? ____

☐ Annað, hvað? _____Hér má til dæmis nefna íþróttagrein þó þú hafir ekki keppt í henni. Hversu margar klukkustundir í viku að jafnaði? ____

Ef þú stundaðir aðra markvissa þjálfun á fyrstu meðgöngu, á hvaða mánuði meðgöngu hættir þú því? (svaraðu miðað við það sem þú hættir síðast að þjálfa)

Vinsamlegast skrifaðu svar þitt hér: _____

Dæmi: Ef þú þjálfaðir þar til á 4. mánuði ritaðu þá 4 í reitinn. Ef þú þjálfaðir alla meðgönguna, ritaðu þá 9 í reitinn.

Gerðir þú grindarbotnsæfingar á fyrstu meðgöngu? (æfingar fyrir vöðvana í kring um þvagrás, leggöng og endaþarm)

Vinsamlegast veldu aðeins eitt af eftirfarandi:

- [ ] Nei
- [ ] Ég man það ekki
- [ ] Já, daglega
- [ ] Já, að minnsta kosti þrisvar í viku
- [ ] Já, einu sinni til tvisvar í viku
- [ ] Já, einu sinni í viku eða sjaldnar
- [ ] Já, stundum, þegar mér fannst ég þurfa þess

Hvað marga samdrætti/æfingar gerðir þú að jafnaði á dag þegar þú gerðir grindarbotnsæfingar?

Vinsamlegast skrifaðu svar þitt hér: _____

Hvað hélstu hverjum samdrætti í margar sekúndur að jafnaði þegar þú gerðir grindarbotnsæfingar?

Vinsamlegast skrifaðu svar þitt hér: _____ sekúndur

Varstu almennt séð líkamlega virk á þinni fyrstu meðgöngu? (hér er verið að tala um almenna daglega virkni sem getur falið í sér að ganga og hjóla til og frá vinnu og felur almennt séð EKKI í sér keppni)

Vinsamlegast veldu aðeins eitt af eftirfarandi:

☐ Nei

☐ Já, en ekki reglulega

☐ Já, reglulega

Almenn líkamleg virkni er sú hreyfing sem hvorki flokkast undir keppnisíþróttir né aðra markvissa þjálfun. Gætið að því að endurtaka ekki það sem búið var að greina frá.

Merktu við tegund þjálfunar og hvað þú hreyfðir þig mikið að jafnaði á fyrstu meðgöngu

Vinsamlegast veldu allt sem við á:

☐ Hæg ganga. Hversu margar klukkustundir í viku að jafnaði? ____

☐ Hröð ganga. Hversu margar klukkustundir í viku að jafnaði? ____

☐ Skokk/hlaup. Hversu margar klukkustundir í viku að jafnaði? ____

☐ Fjölbreytt leikfimi með kennara/eróbikk. Hversu margar klukkustundir í viku að jafnaði? ____

☐ Tækjaþjálfun í sal. Hversu margar klukkustundir í viku að jafnaði? ____

☐ Dans. Hversu margar klukkustundir í viku að jafnaði? ____

☐ Sund. Hversu margar klukkustundir í viku að jafnaði? ____

☐ Hjólreiðar. Hversu margar klukkustundir í viku að jafnaði? ____

☐ Annað, hvað? _____ Hversu margar klukkustundir í viku að jafnaði? ____

Ef þú varst almennt séð líkamlega virk á þinni fyrstu meðgöngu, á hvaða mánuði meðgöngu hættir þú þinni almennu líkamlegu virkni? Miðaðu við það sem þú hættir síðast að stunda.

Vinsamlegast skrifaðu svar þitt hér: ____

Dæmi: Ef þú varst virk fram að 4. mánuði meðgöngu ritaðu þá 4 í reitinn. Ef þú varst almennt séð líkamlega virk alla meðgönguna ritaðu þá 9.

Kærar þakkir fyrir þátttökun