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Sex-Specific Differences in Vertical Jump Force–Time Metrics in Youth Basketball Players

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Abstract: Objective: The purpose of this study was to investigate differences in countermovement jump (CMJ) force–time metrics between male and female youth basketball players. Methods: Twenty-two female and seventeen male basketball players (ages 12–16) performed CMJs on a portable force plate system (VALD Performance). The data collected were analyzed for differences in force–time characteristics, specifically during the concentric and eccentric phases of the CMJ. Results: The results showed no statistically significant differences in anthropometric characteristics between the sexes. However, male athletes demonstrated better performance in several force–time metrics during the concentric phase of the CMJ, including concentric impulse, peak velocity, and mean power, ultimately leading to higher vertical jump heights. Sex-specific differences in the eccentric phase were less pronounced, though males exhibited greater relative eccentric mean power. Conclusions: The findings suggest that male players tend to display greater force and power-producing capabilities during the propulsive (concentric) phase of the CMJ. These differences highlight the importance of tailoring training programs to address specific needs, particularly focusing on enhancing concentric force and power production in female basketball players.

Keywords: basketball; eccentric; concentric; male; female; monitoring; biomechanics

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1. Introduction

Basketball is a globally acclaimed sport, with millions of participants of different ages and cultural backgrounds playing at professional or recreational competitive levels [1]. The fast-paced and dynamic nature of the game requires players to possess a complex combination of technical and tactical skills and physical performance characteristics [2]. Basketball players are required to navigate the court with precision while performing rapid change-of-direction and explosive jumping maneuvers in order to score points and help the team secure a winning game outcome [3]. As players progress through different age groups, the physical and physiological demands of the game evolve, which presents unique challenges and opportunities for further performance improvements [4]. Thus, exploring various performance aspects becomes imperative for a comprehensive understanding of the game of basketball [5].

Previous research has delved into various aspects of the game of basketball, exploring variations in player performance across different categories such as sex [6,7], age [8–10], and playing position [3,11,12]. For example, in a sex-specific context, it has been found that the physical and physiological demands faced by male and female basketball players are relatively similar at the elite levels of play [13]. However, contrasting findings were observed at the semi-elite competitive levels, with notable differences being present in strategic approaches [14] and physical and physiological demands [4,15,16]. Overall, the aforementioned research reports indicate that female basketball players tend to jump more frequently, utilize their upper body to a greater extent, and experience longer work-to-rest periods when compared to their male counterparts [4,16]. Moreover, multiple studies have identified differences in players of various age categories [17–19]. The findings suggest that technical skills and physiological capabilities tend to improve as athletes ascend to higher levels of competition [8–10]. Hence, the focus on studying youth athletes is particularly important, as this developmental stage is crucial for the identification of talent and the implementation of age-adequate training interventions [20,21]. Moreover, understanding neuromuscular performance characteristics is essential for optimizing training protocols in youth basketball, where players are in the formative stages of their athletic journey and development [21].

In a basketball-specific setting, the countermovement jump (CMJ) has been commonly used for assessing lower-body neuromuscular performance characteristics [5]. It is a time-efficient and non-invasive testing modality capable of reflecting an athlete's lower-body strength and power capabilities, which are critical for performing both offensive and defensive maneuvers [3,22]. To delve into these aspects, force plates have emerged as an invaluable tool for conducting valid and reliable in-depth neuromuscular performance analyses [11,23]. In the broader basketball context, force plates have been utilized to assess players' jumping strategies [24], injury risk [25], and fatigue-induced neuromuscular performance changes during practice throughout the span of a full competitive season [5,26]. While numerous studies have investigated the neuromuscular determinants of vertical jump performance in adult male and female basketball players [6,15,20,27], there remains a significant gap in the scientific literature in understanding the same performance parameters in youth basketball players.

Thus, the purpose of the present study was to investigate the differences in CMJ force–time metrics between male and female youth basketball players as well as to provide basketball coaches and strength and conditioning practitioners with deeper insights into youth basketball players' capabilities that can be used to improve training methodologies and their on-court playing performance.

2. Materials and Methods

2.1. Participants

Twenty-two female and seventeen male youth basketball players volunteered to participate in the present study. The age range of participants included in the present investigation was 12–16 years old. All participants were active members of the youth basketball team with >2.5 years of playing experience (e.g., club/school teams) and were free of musculoskeletal injuries that could impact the testing procedures and their performance. The testing procedures were previously approved by the University of Iceland Ethical Board (SHV2023-048) and parental consent was obtained for each participant.

2.2. Procedures

Upon arriving at the gym, athletes underwent a standardized warm-up led by their strength and conditioning coach, which included dynamic stretching exercises, such as forward/backpedal jogs, lunges, high knees, butt kicks, carioca, and straight leg kicks. After familiarizing themselves with the testing procedures, each athlete performed three maximal-effort CMJs on a uni-axial force plate system (ForceDecks Max, VALD Performance, Brisbane, Australia) with their hands on their hips throughout the movement. The force plate, sampling at 1000 Hz, was recalibrated between participants. To reduce fatigue, each jump trial was separated by a 15 s rest. The average of the three jumps was used for analysis. Verbal encouragement was provided to ensure maximal effort and focus on generating maximum force.

The study examined force–time metrics selected based on prior research [5,11,26]. During the eccentric phase of CMJ, variables such as braking phase duration, braking impulse, eccentric duration, peak velocity, and various force and power measures were assessed. During the concentric phase, metrics including impulse, concentric duration, peak velocity, and related force and power variables were analyzed. Additional metrics, such as contraction time, jump height, and the modified reactive strength index (RSI) - modified were calculated. Jump height was determined via impulse–momentum calculation, and RSI-modified was calculated by dividing jump height by contraction time. The contraction time began when the athlete's system mass decreased by 20 N, starting at movement onset and ending at take-off. Take-off was defined when vertical force dropped below 20 N. The eccentric phase was identified as the phase with the negative center of mass velocity, with the braking phase being a sub-phase starting at minimum force and ending with the eccentric phase. Impulse for each sub-phase was calculated as the area under the force–time curve. A sample force–time curve and sub-phase definitions can be found in the VALD user manual (https://valdperformance.com/forcedecks/ [Accessed on 1 October 2020]).

2.3. Statistical Analysis

Shapiro–Wilk test and Q-Q plots were used to assess if the dependent variables met the assumption of normality. Independent t-tests were used to examine between-group statistically significant differences for normally distributed variables (mean and standard deviation), and Mann–Whitney U tests for the variables that violated the assumption of normality (median and interquartile range). The percentage difference was calculated for each dependent variable. Statistical significance was set a priori to $p < 0.05$. All statistical analyses were completed with SPSS (Version 26.0; IBM Corp., Armonk, NY, USA).

3. Results

Descriptive statistics for each dependent variable examined in this investigation are presented in Table 1. No statistically significant differences were observed between male and female youth basketball players in anthropometric characteristics (i.e., height, body mass, age, body mass index). When examining the CMJ force–time metrics within the eccentric phase of the movement, the only statistically significant difference between the two groups was found in eccentric mean power/body mass (BM), with greater values being detected in male than female basketball players. On the other hand, male basketball players demonstrated superior values in all force–time metrics examined within the concentric phase of the CMJ, except concentric peak force, concentric mean force, concentric mean force/BM, and concentric peak power. Moreover, concentric duration, impulse, impulse/BM, peak velocity, peak force/BM, peak power/BM, mean power, and mean power/BM were notably greater in male when compared to female basketball players.

Table 1. Descriptive data and comparison statistics, including percentage difference, between male and female youth basketball players for each dependent variable examined in the present study presented as a mean (standard deviation) or median (interquartile range).

Variable [Unit]	Females	Males	*p*-Value	%-Diff
Anthropometric characteristics				
Height [cm]	162.1 (7.1)	166.9 (8.6)	0.067	2.9
Body mass [kg] #	55.9 (7.8)	57.8 (14.6)	0.660	3.3
Age [years] #	13.0 (1.0)	13.0 (1.5)	0.585	0
BMI [kg·m^2]	20.5 (4.2)	21.2 (2.3)	0.485	3.3
Eccentric phase				
Braking phase duration [s]	0.32 (0.08)	0.36 (0.08)	0.148	11.5
Eccentric braking impulse [N·s] #	33.6 (12.5)	39.7 (13.5)	0.190	16.6
Eccentric braking impulse/BM [N·s] #	0.6 (0.28)	0.7 (0.27)	0.092	20.8
Eccentric duration [s] #	500.0 (119.5)	549.9 (225.5)	0.190	9.5
Eccentric peak velocity [m·s^{-1}]	0.77 (0.26)	0.91 (0.25)	0.103	16.2

Table 1. *Cont.*

Variable [Unit]	Females	Males	*p*-Value	%-Diff
Eccentric peak force [N]	1177.9 (255.3)	1159.7 (343.3)	0.851	1.6
Eccentric peak force/BM [N]	21.2 (3.5)	20.9 (2.8)	0.745	1.4
Eccentric mean force [N]	548.9 (74.5)	567.3 (164.3)	0.673	3.3
Eccentric mean force/BM [N] #	9.8 (0.3)	9.8 (0.1)	0.701	0
Eccentric peak power [W] #	733.0 (596.5)	928.0 (670.0)	0.163	23.5
Eccentric peak power/BM [W] #	13.1 (8.7)	15.2 (6.1)	0.098	14.8
Eccentric mean power [W]	291.0 (105.5)	366.2 (136.5)	0.060	22.9
Eccentric mean power/BM [W] #	4.8 (2.0)	6.3 (1.9) *	0.023	27.0
Concentric phase				
Concentric duration [s]	0.265 (0.049)	0.301 (0.053) *	0.034	12.7
Concentric impulse [N·s]	121.6 (19.9)	157.5 (55.8) *	0.020	25.7
Concentric impulse/BM [N·s]	2.2 (0.3)	2.7 (0.6) *	0.002	20.4
Concentric peak velocity [m·s^{-1}]	2.3 (0.3)	3.2 (0.8) *	<0.001	32.7
Concentric peak force [N] #	1328.5 (335.8)	1307.0 (614.5)	0.769	1.6
Concentric peak force/BM [N] #	24.2 (3.6)	26.1 (4.0) *	0.042	7.6
Concentric mean force [N]	1058.5 (167.9)	1088.1 (344.8)	0.748	2.8
Concentric mean force/BM [N]	19.1 (2.0)	20.5 (2.9)	0.087	7.1
Concentric peak power [W] #	2728.0 (1223.7)	3431.0 (2154.5)	0.440	22.8
Concentric peak power/BM [W] #	46.4 (11.9)	67.2 (27.5) *	0.042	36.6
Concentric mean power [W]	1282.5 (282.9)	1689.5 (638.1) *	0.023	27.4
Concentric mean power/BM [W] #	24.2 (7.2)	29.8 (10.9) *	<0.001	20.7
Performance indicators				
Contraction time [s]	0.804 (0.186)	0.879 (0.204)	0.235	8.9
Jump height [cm]	29.8 (10.5)	39.3 (14.5) *	0.023	27.5
RSI-modified [ratio]	0.429 (0.120)	0.482 (0.142)	0.217	11.6

Note: BMI—body mass index; RSI—reactive strength index; # non-normally distributed variable; %-diff—percentage difference; * significantly different when compared to female basketball players ($p < 0.05$).

In addition, while contraction time and RSI-modified were similar in magnitude between the two groups, vertical jump height was significantly greater for male than female basketball players (Table 1).

4. Discussion

To the best of the authors' knowledge, this is the first investigation focused on a comprehensive analysis of lower-body neuromuscular performance characteristics in youth male and female basketball players (i.e., 12–16 years old). While anthropometric characteristics (e.g., height, body mass, age, body mass index) did not differ between the two groups, the results revealed notable differences in multiple CMJ force–time metrics of interest (e.g., concentric peak velocity, concentric peak force/BM, eccentric mean power/BM, concentric duration and impulse).

Previous research has indicated that the average height of female basketball players competing in the Ukrainian league was 167.8 cm [28]. Our results suggest that the male athletes were taller than their Italian counterparts, who had an average height of 155.2 cm [29]. Also, Drinkwater et al. [30] reported an average height of 164.9 cm and body weight of 57.2 kg in female basketball players, which is comparable to our sample of female participants. Torres-Unda et al. [31] investigated male basketball players who were 13 years old and found an average height of 182.5 cm and weight of 67 kg. Additionally, Rinaldo et al. [29] observed lower average heights and weights (i.e., 155.2 cm and 47.6 kg) compared to our male sample, while Jakovljevic et al. [32] reported an average height of 175.7 cm and weight of 57 kg for youth male basketball players.

When focused on examining the eccentric and concentric phases of the CMJ, distinct sex-specific differences were observed. Within the eccentric phase of the CMJ, only one statistically significant difference was noted, with male players exhibiting greater eccentric mean power/BM when compared to their female counterparts. On the other hand, within the concentric phase of the CMJ, male basketball players demonstrated superior performance across multiple force–time metrics. Specifically, they attained greater concentric duration, impulse, impulse/BM, peak velocity, peak force/BM, peak power/BM, mean power, and mean power/BM compared to their female counterparts. Overall, these findings suggest that male athletes have a notable advantage in force and power-generating capabilities during the propulsive phase of the jump, which likely contributes to their superior vertical jump performance [33–35]. For example, in the concentric phase of the CMJ, male players demonstrated significantly higher concentric peak power/BM (67.2 W/kg vs. 46.4 W/kg), concentric mean power/BM (29.8 W/kg vs. 24.2 W/kg), and concentric impulse/BM (2.7 Ns/kg vs. 2.2 N·s/kg). Also, despite not reaching the level of statistical significance, male players attained higher eccentric braking impulse/BM by 20.8% (0.7 Ns/kg vs. 0.6 Ns/kg) and eccentric peak power/BM by 14.8% (15.2 W/kg vs. 13.1 W/kg).

When compared to other levels of basketball competition, the magnitudes of the aforementioned force–time metrics were lower in our study. Torres-Unda et al. [31] reported a vertical jump height of 43.9 cm, Jakovljevic et al. [32] 43.2 cm, and Drinkwater et al. [30] 45.6 cm, all of which are higher than the values observed in the present study. Moreover, Chukhlantseva et al. [28] examined youth female basketball players and found an average vertical jump height of 39.7 cm for female athletes, which is also greater than the values obtained in this investigation. These differences can be attributed to the age-specific differences or maturation statuses, suggesting that our cohort of participants was younger and/or less mature.

This study presents an analysis of performance metrics normalized by BM, revealing multiple sex-specific differences among youth basketball players. While anthropometric characteristics were similar between male and female players, several key discrepancies were observed in BM-dependent force–time metrics. Indeed, jump height was significantly greater in male than female basketball players. However, variables such as contraction time and RSI-modified did not show sex-specific differences. This suggests that certain variables may not be capable of depicting differences in CMJ performance between these two groups of basketball players.

These findings may benefit basketball coaches and strength and conditioning practitioners when developing individually tailored training regimens directed toward the optimization of force and power-producing capabilities. Also, these results underscore the importance of considering sex-specific differences in the talent identification and player development process within youth basketball programs. Considering the observed performance differences, coaches and sports practitioners may consider implementing training regimes targeted toward optimizing concentric force and power-producing capabilities in female athletes. Moreover, given the challenges associated with predicting athletic potential in pre-adolescents and adolescents, it is beneficial for coaches to consider individual maturation rates and differences in physical development. In addition, regularly conducting assessments of this nature such as CMJ may be beneficial to allow for the identification of individual athlete needs.

The force–time metrics examined in the present study may help with the talent identification process, as they may offer a better understanding of an athlete's neuromuscular performance capabilities. For instance, the RSI-modified can highlight an athlete's ability to utilize elastic energy during jumping, while jump height reflects overall lower-body power output. Additionally, assessing concentric and eccentric durations can reveal an athlete's efficiency in force production and control during dynamic movements. Thus, incorporating CMJ assessments into talent identification protocols can facilitate a more objective evaluation process, ensuring that promising athletes are recognized and nurtured, even if their potential is not immediately apparent through traditional observational methods (e.g., on-court performance). This data-driven approach can enhance the development of training regimens tailored to individual strengths and weaknesses, ultimately fostering improved athletic performance and successful long-term athlete development.

Although this study offers deeper insight into lower-body neuromuscular performance qualities of youth athletes, it is not without limitations. The study included a relatively small sample size, which may not be representative of the larger population of youth basketball players. Also, the participants were selected from a specific age group (12–16 years old) and from a similar geographic location, which might limit the generalizability of the findings to other age groups or regions. Also, the testing processes were conducted at a single time point. So, longitudinal monitoring (i.e., multiple testing time points) is needed to understand how the observed sex-specific performance differences evolve with age and training.

5. Conclusions

The findings of the present study revealed significant sex-specific differences in multiple force–time metrics of interest, particularly within the concentric phase of the CMJ, with male athletes exhibiting superior performance. While anthropometric characteristics were similar between the sexes, male athletes displayed superior force and power-producing capabilities than female athletes. Specifically, the male athletes attained greater absolute and relative concentric impulse, concentric peak velocity, relative concentric peak force, and absolute and relative mean power than their female counterparts. Also, male athletes had greater vertical jump heights, while no difference was observed in contraction time and RSI-modified. Overall, these findings provide reference values for this specific group of youth basketball players and can be used by coaches and strength and conditioning practitioners when developing individually tailored training regimens.

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Informed Consent Statement: Informed consent was obtained from all subjects in this study.

Data Availability Statement: Data are available upon request.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Dadelo, S.; Turskis, Z.; Zavadskas, E.K.; Dadeliene, R. Multi-criteria assessment and ranking system of sport team formation based on objective-measured values of criteria set. *Expert. Syst. Appl.* **2014**, *41*, 6106–6113. [CrossRef]
2. Cabarkapa, D.; Deane, M.; Fry, A.; Jones, G.; Cabarkapa, D.V.; Philipp, N.; Yu, D. Game statistics that discriminate winning and losing at the NBA level of basketball competition. *PLoS ONE* **2022**, *17*, e0273427. [CrossRef] [PubMed]
3. Ben Abdelkrim, N.; Castagna, C.; Jabri, I.; Battikh, T.; Fazaa, S.; Jalila, A.; Atli, E.L. Activity profile and physiological requirements of junior elite basketball players in relation to aerobic-anaerobic fitness. *J. Strength. Cond. Res.* **2010**, *24*, 2330–2342. [CrossRef] [PubMed]
4. Gutierrez-Vargas, R.; Morillo-Baro, J.P.; Reigal, R.E.; Hernández-Mendo, A. Análisis del ataque posicional de balonmano playa masculino y femenino mediante coordenadas polares. *Rev. Int. Cienc. Deporte* **2022**, *11*, 226–244. [CrossRef]
5. Cabarkapa, D.; Cabarkapa, D.V.; Aleksic, J.; Philipp, N.M.; Scott, A.A.; Johnson, Q.R.; Fry, A.C. Differences in countermovement jump force-time metrics between starting and non-starting professional male basketball players. *Front. Sports Act Living* **2023**, *5*, 1327379. [CrossRef]
6. Laffaye, G.; Wagner, P.P.; Tombleson, T.I.L. Countermovement jump height: Gender and sport-specific differences in the force-time variables. *J. Strength Cond. Res.* **2014**, *28*, 1096–1105. [CrossRef]
7. Ziv, G.; Lidor, R. Physical Attributes, Physiological Characteristics, On-Court Performances and Nutritional Strategies of Female and Male Basketball Players. *Sports. Med.* **2009**, *39*, 547–568. [CrossRef]
8. Ibáñez, S.J.; Mazo, A.; Nascimento, J.; García-Rubio, J. The Relative Age Effect in under-18 basketball: Effects on performance according to playing position. *PLoS ONE* **2018**, *13*, e0200408. [CrossRef]
9. Kellis, S.E.; Tsitskaris, G.K.; Nikopolou, M.D.; Mousikou, K.C. The Evaluation of Jumping Ability of Male and Female Basketball Players According to Their Chronological Age and Major Leagues. *J. Strength Cond. Res.* **1999**, *13*, 40–46. [CrossRef]

10. Rösch, D.; Ströbele, M.G.; Leyhr, D.; Ibáñez, S.J.; Höner, O. Performance Differences in Male Youth Basketball Players According to Selection Status and Playing Position: An Evaluation of the Basketball Learning and Performance Assessment Instrument. *Front. Psychol.* **2022**, *13*, 859897. [CrossRef]
11. Cabarkapa, D.; Philipp, N.; Cabarkapa, D.V.; Eserhaut, D.; Fry, A. Comparison of Force-Time Metrics Between Countermovement jump With and Without an Arm Swing in Professional Male Basketball Players. *Int. J. Strength Cond.* **2023**, *3*, 1–7. [CrossRef]
12. Pehar, M.; Sekulic, D.; Sisic, N.; Spasic, M.; Uljevic, O.; Krolo, A.; Milanovic, Z.; Sattler, T. Evaluation of different jumping tests in defining position-specific & performance-level differences in high level basketball players. *Biol. Sport.* **2017**, *34*, 263–272. [CrossRef] [PubMed]
13. Stojanović, E.; Stojiljković, N.; Scanlan, A.T.; Dalbo, V.J.; Berkelmans, D.M.; Milanović, Z. The Activity Demands and Physiological Responses Encountered During Basketball Match-Play: A Systematic Review. *Sports Med.* **2018**, *48*, 111–135. [CrossRef] [PubMed]
14. Pic Aguilar, M. Different motor patterns in basketball depending on gender? *Cuad. Psicol. Deporte* **2017**, *17*, 149–156.
15. Rice, P.E.; Goodman, C.L.; Capps, C.R.; Triplett, N.T.; Erickson, T.M.; McBride, J.M. Force– and power–time curve comparison during jumping between strength-matched male and female basketball players. *Eur. J. Sport. Sci.* **2017**, *17*, 286–293. [CrossRef]
16. Scanlan, A.T.; Dascombe, B.J.; Kidcaff, A.P.; Peucker, J.L.; Dalbo, V.J. Gender-Specific Activity Demands Experienced During Semiprofessional Basketball Game Play. *Int. J. Sports. Physiol. Perform.* **2015**, *10*, 618–625. [CrossRef]
17. Latzel, R.; Hoos, O.; Stier, S.; Kaufmann, S.; Fresz, V.; Reim, D.; Beneke, R. Energetic Profile of the Basketball Exercise Simulation Test in Junior Elite Players. *Int. J. Sports Physiol. Perform.* **2018**, *13*, 810–815. [CrossRef]
18. Mancha-Triguero, D.; García-Rubio, J.; Antúnez, A.; Ibáñez, S.J. Physical and Physiological Profiles of Aerobic and Anaerobic Capacities in Young Basketball Players. *Int. J. Environ. Res. Public Health* **2020**, *17*, 1409. [CrossRef]
19. Pérez-Ifrán, P.; Rial, M.; Brini, S.; Calleja-Gonzales, J.; Del Rosso, S.S.; Boullosa, D.; Benitez-Flores, S. Change of Direction Performance and its Physical Determinants Among Young Basketball Male Players. *J. Hum. Kinet.* **2022**, *85*, 23–34. [CrossRef]
20. Sar, C.É.; Meylan, M.P.; Cronin, J.B.; Oliver, J.L.; Rumpf, M.C. Sex-related differences in explosive actions during late childhood. *J. Strength Cond. Res.* **2021**, *28*, 2097–2104. [CrossRef]
21. Zoellner, A.; Whatman, C.; Read, P.; Sheerin, K. The association between sport specialisation and movement competency in youth: A systematic review. *Int. J. Sports Sci. Coach.* **2001**, *16*, 1045–1059. [CrossRef]
22. Scanlan, A.; Dascombe, B.; Reaburn, P. A comparison of the activity demands of elite and sub-elite Australian men's basketball competition. *J. Sports Sci.* **2011**, *29*, 1153–1160. [CrossRef] [PubMed]
23. Anicic, A.; Janicijevic, D.; Knezevic, O.M.; Garcia-Ramos, A.; Petrovic, M.R.; Cabarkapa, D.; Mirkov, D.M. Assessment of Countermovement Jump: What Should We Report? *Life* **2023**, *13*, 190. [CrossRef] [PubMed]
24. Rauch, J.; Leidersdorf, E.; Reeves, T.; Borkan, L.; Elliott, M.; Ugrinowitsch, C. Different movement strategies in the countermovement jump amongst a large cohort of NBA players. *Int. J. Environ. Res. Public Health* **2020**, *17*, 6394. [CrossRef]
25. Heishman, A.; Daub, B.; Miller, R.; Brown, B.; Freitas, E.; Bemben, M. Countermovement jump inter-limb asymmetries in collegiate basketball players. *Sports* **2019**, *7*, 103. [CrossRef]
26. Philipp, N.M.; Cabarkapa, D.; Nijem, R.M.; Fry, A.C. Changes in countermovement jump force-time characteristic in elite male basketball players: A season-long analyses. *PLoS ONE* **2023**, *18*, e0286581. [CrossRef]
27. Mihajlovic, M.; Cabarkapa, D.; Cabarkapa, D.V.; Philipp, N.M.; Fry, A.C. Recovery methods in basketball: A systematic review. *Sports* **2023**, *11*, 230. [CrossRef]
28. Chukhlantseva, N.; Cherednichenko, I.; Bruhno, E. Comparative characteristics and assessment of the relations of anthropometric indicators and motor abilities of girls' basketball players 12-14 years old. *Cent. Eur. J. Sport Sci. Med.* **2021**, *33*, 61–71. [CrossRef]
29. Rinaldo, N.; Toselli, S.; Gualdi-Russo, E.; Zedda, N.; Zaccagni, L. Effects of anthropometric growth and basketball experience on physical performance in pre-adolescent male players. *Int. J. Environ. Res. Public Health* **2020**, *17*, 2196. [CrossRef]
30. Drinkwater, E.J.; Pyne, D.B.; Mckenna, M.J. Design and Interpretation of Anthropometric and Fitness Testing of Basketball Players. *Sports. Med.* **2008**, *38*, 565–578. [CrossRef]
31. Torres-Unda, J.; Zarrazquin, I.; Gravina, L.; Zubero, J.; Seco, J.; Gil, S.M.; Gil, J.; Irazusta, J. Basketaball performances is related to maturity and relative age in adolescent players. *J. Strength Cond. Res.* **2016**, *30*, 1325–1332. [CrossRef] [PubMed]
32. Jakovljevic, S.; Macura, M.; Radivoj, M.; Jankovic, N.; Pajic, Z.; Erculj, F. Biological Maturity Status and Motor Performance in Fourteen-Year-old Basketball Players. *Int. J. Morphol.* **2016**, *34*, 637–642. [CrossRef]
33. Schade, F.; Arampatzis, A.; Brüggemann, G.P.; Komi, P.V. Comparison of the men's and the women's pole vault at the 2000 Sydney Olympic Games. *J. Sports. Sci.* **2004**, *22*, 835–842. [CrossRef]
34. Márquez, G.; Alegre, L.M.; Jaén, D.; Martin-Casado, L.; Aguado, X. Sex differences in kinetic and neuromuscular control during jumping and landing. *J. Electromyogr. Kinesiol.* **2013**, *23*, 747–758. [CrossRef]
35. Ford, K.R.; Myer, G.D.; Toms, H.E.; Hewett, T.E. Gender differences in the kinematics of unanticipated cutting in young athletes. *Med. Sci. Sports. Exerc.* **2005**, *37*, 124–129. [CrossRef]

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