biomechanics

MDPI

Article

Normative Data for Vertical Jump Tests in Pre-School Children Aged 3 to 6 Years

Vilko Petrić [1], Sanja Ljubičić [1,*] and Dario Novak [2]

[1] Faculty of Teacher Education, University of Rijeka, 51000 Rijeka, Croatia; vilko.petric@uniri.hr
[2] Faculty of Kinesiology, University of Zagreb, 10000 Zagreb, Croatia; dario.novak@kif.hr
* Correspondence: sanja.ljubicic@uniri.hr; Tel.: +385-51265819

Abstract

Background/Objectives: Vertical jump is considered a reliable and valid method of assessing the level of muscular power and coordination across one's lifespan. The main aim of the present study was to establish sex- and age-normative data for vertical jump outcomes in pre-school children. **Methods**: We recruited 411 boys and girls aged 3−6 years from four major cities in Croatia and Slovenia. Vertical jump was assessed with two tests: countermovement jump (CMJ) without and with arm swing using a reliable and valid Optojump measuring platform. Data were presented for the 5th, 15th, 25th, 50th (median), 75th, 90th, and 95th percentile. **Results**: No significant differences were observed in multiple vertical jump outcomes between boys and girls. The mean values for CMJ without and with arm swing between boys and girls were as follows: contact time (1.4 vs. 1.4 s/1.8 vs. 1.7 s), flight time (0.32 vs. 0.31 s/0.33 vs. 0.32), height (12.3 vs. 12.2 cm/13.0 vs. 12.5 cm), power (9.4 vs. 9.5 W/kg/9.3 vs. 9.1 W/kg), pace (0.7 vs. 0.7 steps/s/0.6 vs. 0.6 steps/s), reactive strength index (RSI; 0.10 vs. 0.09 m/s/0.08 vs. 0.08 m/s), and verticality (2.5 vs. 2.3/1.9 vs. 1.9). A gradual increase in all measures according to 'age' was observed (p for trend < 0.05). No significant 'sex*age' interaction was observed ($p > 0.05$). **Conclusions**: This is one of the first studies to provide sex- and age-normative data for complete vertical jump outcomes in pre-school children. These data will serve as an avenue for monitoring and tracking motor development in this sensitive period.

Keywords: countermovement jump; motor development; 3–6-year-olds; power; jump height; sex; age

check for updates

Academic Editor: François Prince

Received: 16 May 2025
Revised: 15 July 2025
Accepted: 17 July 2025
Published: 1 August 2025

Citation: Petrić, V.; Ljubičić, S.; Novak, D. Normative Data for Vertical Jump Tests in Pre-School Children Aged 3 to 6 Years. *Biomechanics* **2025**, *5*, 56. https://doi.org/10.3390/biomechanics5030056

1. Introduction

The pre-school period represents a crucial time frame for children to develop fundamental movements in order to execute and perfect various motor skills [1]. The ability to perform these movements at an adequate level during the pre-school years may be beneficial for enhancing or at least maintaining these skills during childhood and adolescence [2]. Among pre-school children, some atypical movement patterns may be explained by insufficient maturation of their motor skills and senso-motoric control [3]. This is particularly true for locomotor skills [4], as preschool children still lack fully developed neuro-muscular coordination, lower limb stiffness, joint dynamics, and arm swing characteristics [5].

The most commonly used assessment of the level of muscular power during locomotor performance is the vertical jump test [6]. It is characterized as a stretch-shortening cycle movement with the initial lengthening and rapid shortening of a muscle–tendon unit [7].

The vertical jump test has been widely applied in sports for talent identification [8,9], neuromuscular readiness, and fatigue [10]. The hierarchical model of motor development places vertical jump at the base of its pyramidal structure, identifying it as a fundamental motor pattern upon which more complex motor skills are progressively built throughout one's lifespan [11].

To quantify and monitor performance in different populations, either criterion-referenced cut-points or normative standards are needed. The ability to distinguish between certain sociodemographic characteristics, like sex and age, may be useful for comparing an individual child's performance to those of sex- and age-standardized norms [12]. Also, the utility of using such approach benefits in terms of assessing whether a child has typical motor skill development for their age.

Although normative data for vertical jump have been reported in school-going children [13–18], only a handful of studies on this topic have been conducted in pre-school children [6,12,19,20]. The existing literature has shown that the vertical jump height of 6-year-olds is 20.4 cm for boys and 21.9 cm for girls [6], and a study [20] reported mean jump heights of 11.9 cm and 12.5 cm for 3–6-year-old boys and girls, respectively. Although one study failed to directly measure vertical jump, normative data for the Test of Gross Motor Development (TGMD-3) indicated a rapid increase in the sum of the TGMD-3 and locomotor skill set from 3 to 6 years of age, after which the values plateaued from the age of 7 to 11 years [12]. In Chinese pre-school children aged 3−5 years, a linear increase in standing broad jump was observed, irrespective of sex [19]. This implies that pre-school age is a very sensitive period for vertical jump development, especially for children between 3 and 6 years old. When sex differences are accounted for, it seems that girls outperform boys in vertical jump height [20], while other studies have found no differences between them [6].

The discrepancy between studies comes from more intra-subject variability, where pre-school children still have inconsistent muscle activity patterns, which is mainly observed in more eccentric muscle contraction during the pushing and landing phase [21]. Naturally, the ratio between brain and perception ability and neuromuscular development growth in pre-school children is different, where both brain and movement perception mature more rapidly, while the connection between neural and muscular systems develops more gradually [22]. Another possible reason for data inconsistency comes from the different tests used to determine muscle strength and test equipment used to establish normative data for vertical jump. Finally, evidence from previous studies highlights that height is the only parameter of vertical jump that has been evaluated in pre-school children [6,12,20], yet other important outcomes of vertical jump, like power, the reactive strength index (RSI), or verticality, have yet to be investigated.

Therefore, the main aim of the present study was to examine the jumping characteristics of 3–6-year-old boys and girls and to establish sex- and age-specific normative data for jump-related outcomes. Based on previous findings on age [12,19,20] and sex [6], we hypothesized that all jump parameters would increase with age and no differences between boys and girls would be observed.

2. Materials and Methods

2.1. Study Participants

A convenient sample of 411 pre-school boys and girls aged 3–6 years from the four European cities of Rijeka (Croatia), Zagreb (Croatia), Ljubljana (Slovenia), and Koper (Slovenia) were recruited in this observational, cross-sectional study: mean (SD) [age = 4.9 (1.1) years, height = 111.2 (9.3) cm, weight = 20.0 (4.2) kg, 53.5% girls]. The inclusion criteria involved children aged 3–6 years with typical development, without any locomotor or mental disorders or diseases, and who were enrolled in day care. Before entering this study, parents or guardians were informed on the main aims and hypotheses of this study, the dissemination of the findings, and potential benefits for their children. Each child's parents/guardians provided informed consent before data collection. As this research involved human subjects, it was conducted in compliance with all relevant national regulations and institutional policies, in accordance with the tenets of the Helsinki Declaration [23], and with approval from the Faculty of Teacher Education, University of Rijeka.

2.2. Data Analysis

Before analyses, we tested each parameter for data normality using the Kolmogorov–Smirnov (K-S) test. For normally distributed variables, the data were presented as the mean and standard deviation (SD), while the median and interquartile range (IQR) were calculated for data that failed to follow a normal distribution. The main effects for 'sex' (boys vs. girls), 'age' (3 to 6 years), and the interaction term of 'sex*age' were examined using a two-factor analysis of variance (ANOVA) or Kruskal–Wallis H-test with a Bonferroni post hoc comparison analysis between each group. Between-group differences were calculated using Student's *t*-test or the Mann–Whitney Z-test for independent samples. For each variable, we determined sex- and age-specific percentile values (5th, 15th, 25th, 50th, 75th, 90th, and 95th). Correlation coefficients between age and jumping outcomes were examined using Pearson's model. All analyses were performed with the Statistical Packages for Social Sciences version 24 (SPSS Inc., Chicago, IL, USA), and significance was set at $\alpha < 0.05$.

2.3. Jumping Performance

The vertical jump test was evaluated using the Optojump photocell system (Microgate, Bolzano, Italy), a reliable and valid infrared platform that consists of two parallel bars (receiver and transmitter units) [24]. Each bar was placed 1 m apart in a parallel position and was connected to a personal computer equipped with software to quantify jump height [24]. When a person jumps, their feet interrupt the infrared beam between the two parallel bars, triggering the sensors to start recording the flight time at a rate of 1000 Hz. The flight time of vertical jumps was measured with an accuracy of 1/1000 s, and the estimated jump height was calculated using the following formula: 9.81 $\times$ flight time 2/8 [25]. To determine jumping outcomes, we selected two tests: countermovement jump (CMJ) without arm swing and CMJ with arm swing [24]. From a kinematic perspective, children were instructed to start both tests from the standing position with their trunk and knees fully extended and their feet set shoulder-width apart, after which they executed a fast downward movement with approximately 90° knee flexion and a fast upward movement to jump as high as possible while keeping their hands on their hips throughout the whole movement (CMJ without arm swing) or while swinging their arms back during the downward movement and forward during the upright movement (CMJ with arm swing) [26]. Each test was performed 5 times with a 5 min rest period between each trial. CMJ tests have been extensively used to assess vertical performance and power output, and their reliability, validity, and utility properties have been confirmed in children [26]. The Optojump software (Microgate S.r.l., version 1.13.24.0, 2009–2023) automatically generated data regarding contact time (s), flight time (s), jump height (cm), power (W/kg), pace (steps/s), and verticality [27] apart from the RSI, which was calculated by dividing jump height by ground contact time. The sequence of photographs in Figure 1 illustrates the phases of performing a countermovement jump with and without arm swing.

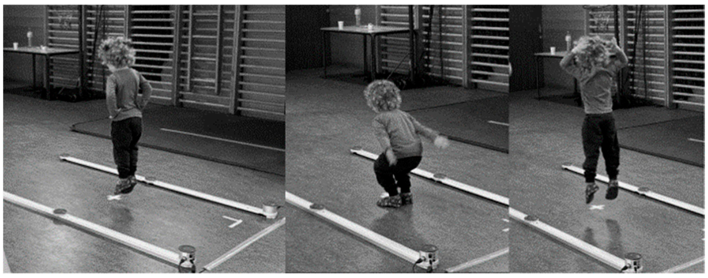

Figure 1. CMJ without arm swing and CMJ with arm swing.

3. Results

Basic descriptive statistics of the study participants are presented in Table 1.

Table 1. Characteristics of study participants, according to sex, with data presented as mean (SD) or median (IQR).

Study Variables	Total (*N* = 405)	Boys (*N* = 186)	Girls (*N* = 219)	*p*-Value
Age (years)	4.9 (1.1)	4.9 (1.1)	4.8 (1.1)	0.683
Height (cm)	111.2 (9.3)	111.8 (9.5)	110.8 (9.2)	0.309
Weight (kg)	20.0 (4.2)	20.3 (4.2)	19.7 (4.2)	0.209
BMI (kg/m^2)	15.8 (1.5)	15.9 (1.4)	15.8 (1.6)	0.385
CMJ without arm swing				
Contact time (s)	1.38 (0.99)	1.41 (0.96)	1.36 (1.01)	0.599
Flight time (s)	0.30 (0.05)	0.30 (0.05)	0.30 (0.05)	0.988
Height (cm)	11.3 (3.7)	11.3 (3.8)	11.2 (3.6)	0.890
Power (W/kg)	9.5 (3.3)	9.4 (3.2)	9.5 (3.5)	0.837
Pace (steps/s)	0.69 (0.53–1.11)	0.74 (0.52–1.30)	0.67 (0.53–1.02)	0.231
RSI (m/s)	0.09 (0.06–0.18)	0.10 (0.05–0.19)	0.09 (0.06–0.17)	0.767
Verticality	2.38 (1.29–4.58)	2.50 (1.27–5.01)	2.29 (1.28–4.13)	0.465
CMJ with arm swing				
Contact time (s)	1.69 (1.04)	1.75 (1.19)	1.64 (0.88)	0.313
Flight time (s)	0.32 (0.07)	0.32 (0.05)	0.31 (0.06)	0.245
Height (cm)	12.8 (4.4)	13.0 (4.3)	12.6 (4.4)	0.288
Power (W/kg)	9.2 (2.7)	9.3 (2.8)	9.1 (2.7)	0.563
Pace (steps/s)	0.60 (0.47–0.82)	0.58 (0.44–0.80)	0.60 (0.48–0.82)	0.161
RSI (m/s)	0.08 (0.05–0.12)	0.08 (0.05–0.12)	0.08 (0.05–0.11)	0.736
Verticality	1.85 (0.94–3.78)	1.85 (0.97–3.81)	1.85 (0.88–3.70)	0.492

Abbreviations: BMI (body mass index), RSI (reactive strength index); $p < 0.05$.

Table 2 shows sex- and age-specific data for CMJ outcomes without and with arm swing. When observing differences between boys and girls, no significant main effect for 'sex' was observed, indicating that sex had no role in CMJ performance without arm swing ($p > 0.05$). Interestingly, age-related differences showed a significant main effect for 'age', where for all outcomes for CMJ without arm swing, older boys and girls exhibited higher values (except for contact time, where an inverse trend was observed), compared to younger counterparts ($p < 0.05$). Main effects for 'sex*age' did not reveal significance, indicating that the interaction between boys and girls in the same age category exhibited similar CMJ values without arm swing ($p > 0.05$). Also, for CMJ with arm swing, no significant main effect for 'sex' was observed ($p > 0.05$). Similarly to CMJ without arm swing, 'age' was a significant contributor to jumping outcomes for CMJ with arm swing, where older boys and girls performed better (except for contact time, when an inverse trend was observed) than their younger counterparts ($p < 0.05$). Finally, the interaction of 'sex*age' was not significant, with patterns of change similar to those of CMJ without arm swing ($p > 0.05$).

Table 2. Sex- and age-specific jumping performance for CMJ without and with arm swing, with data presented as mean (SD) or median (IQR).

Sex	Age (years)	Contact Time (s)	Flight Time (s)	Height (cm)	Power (W/kg)	Pace (Steps/s)	RSI (m/s)	Verticality
CMJ without arm swing								
Boys	3 (N = 43)	1.9 (1.2)	0.26 (0.04)	8.5 (2.9)	6.9 (2.0)	0.5 (0.4–0.7)	0.05 (0.03–0.06)	1.6 (1.0–3.9)
	4 (N = 62)	1.4 (0.9)	0.29 (0.05)	10.3 (3.3)	9.3 (3.2)	0.9 (0.5–1.3)	0.10 (0.06–0.19)	2.5 (1.1–4.6)
	5 (N = 42)	1.3 (1.0)	0.31 (0.04)	12.3 (3.2)	10.0 (2.5)	0.8 (0.6–1.4)	0.10 (0.07–0.20)	3.0 (1.5–6.3)
	6 (N = 39)	1.1 (0.7)	0.34 (0.03)	14.6 (2.8)	11.6 (2.9)	1.0 (0.6–1.8)	0.17 (0.10–0.23)	2.9 (1.4–5.7)
	Total (N = 186)	1.4 (1.0)	0.30 (0.05)	11.3 (3.8)	9.4 (3.1)	0.7 (0.5–1.3)	0.10 (0.05–0.19)	2.5 (1.3–5.0)
Girls	3 (N = 62)	1.6 (1.0)	0.26 (0.05)	8.3 (3.1)	7.5 (2.4)	0.6 (0.5–1.0)	0.06 (0.03–0.11)	2.4 (1.5–3.5)
	4 (N = 61)	1.4 (0.7)	0.30 (0.04)	11.1 (2.6)	9.1 (2.7)	0.7 (0.6–0.9)	0.09 (0.06–0.10)	1.9 (1.1–2.9)
	5 (N = 55)	1.2 (0.7)	0.32 (0.04)	12.6 (3.0)	10.2 (2.9)	0.7 (0.6–1.0)	0.09 (0.07–0.21)	2.4 (1.6–4.4)
	6 (N = 41)	1.1 (1.6)	0.34 (0.04)	13.9 (3.1)	12.0 (4.5)	0.9 (0.6–1.5)	0.17 (0.09–0.33)	3.4 (1.6–4.9)
	Total (N = 219)	1.4 (1.0)	0.30 (0.05)	11.2 (3.6)	9.5 (3.5)	0.7 (0.5–1.0)	0.09 (0.06–0.17)	2.3 (1.3–4.1)
CMJ with arm swing								
Boys	3 (N = 43)	2.1 (1.4)	0.27 (0.04)	9.3 (2.8)	7.3 (2.8)	0.6 (0.4–0.7)	0.04 (0.02–0.07)	1.5 (0.8–2.5)
	4 (N = 62)	1.7 (1.0)	0.32 (0.08)	12.0 (3.4)	8.7 (2.3)	0.6 (0.5–0.8)	0.07 (0.05–0.10)	1.6 (0.8–3.6)
	5 (N = 42)	1.7 (1.6)	0.34 (0.04)	14.8 (3.2)	10.3 (2.3)	0.6 (0.5–0.9)	0.10 (0.07–0.13)	2.0 (1.4–3.8)
	6 (N = 39)	1.5 (0.8)	0.36 (0.05)	16.2 (4.1)	11.0 (2.5)	0.6 (0.4–0.9)	0.11 (0.08–0.16)	2.7 (1.5–7.6)
	Total (N = 186)	1.8 (1.1)	0.33 (0.12)	13.0 (4.3)	9.3 (2.8)	0.6 (0.4–0.8)	0.08 (0.05–0.12)	1.9 (1.0–3.8)
Girls	3 (N = 62)	2.0 (1.2)	0.26 (0.06)	8.9 (3.4)	7.1 (2.0)	0.6 (0.4–0.8)	0.05 (0.03–0.07)	1.4 (0.7–2.4)
	4 (N = 61)	1.7 (0.8)	0.31 (0.04)	11.8 (2.9)	8.7 (2.1)	0.6 (0.5–0.9)	0.07 (0.05–0.10)	2.0 (1.0–4.8)
	5 (N = 55)	1.5 (0.9)	0.34 (0.04)	14.3 (3.3)	10.2 (2.6)	0.6 (0.5–0.8)	0.10 (0.08–0.13)	1.8 (0.9–3.1)
	6 (N = 41)	1.4 (0.7)	0.37 (0.04)	16.6 (4.1)	11.4 (2.1)	0.6 (0.5–0.8)	0.12 (0.09–0.16)	2.4 (1.7–5.6)
	Total (N = 219)	1.7 (0.9)	0.31 (0.06)	12.5 (4.4)	9.1 (2.7)	0.6 (0.5–0.8)	0.08 (0.05–0.11)	1.9 (0.9–3.7)

Abbreviations: RSI (reactive strength index); $p < 0.05$.

Tables 3 and 4 exhibit percentile normative data for outcomes related to CMJ without and with arm swing, according to sex and age.

Table 3. Normative data for CMJ without arm swing, according to sex and age.

Measure	Sex	Age (years)	P5	P15	P25	P50 (M)	P75	P90	P95
Contact time (s)	Boys	3 (N = 43)	0.72	1.10	1.27	1.62	2.35	3.09	4.20
		4 (N = 62)	0.30	0.59	0.72	1.20	1.85	2.54	3.15
		5 (N = 42)	0.32	0.46	0.53	1.15	1.53	3.06	3.84
		6 (N = 39)	0.27	0.46	0.61	0.92	1.39	2.32	2.73

Table 3. *Cont.*

Measure	Sex	Age (years)	P5	P15	P25	P50 (M)	P75	P90	P95
Contact time (s)	Girls	3 (N = 62)	0.35	0.81	0.94	1.35	2.03	2.64	3.26
		4 (N = 61)	0.41	0.64	0.94	1.32	1.56	2.16	3.33
		5 (N = 55)	0.32	0.52	0.73	1.16	1.52	2.12	2.58
		6 (N = 41)	0.28	0.35	0.40	0.79	1.35	1.69	2.92
Flight time (s)	Boys	3 (N = 43)	0.18	0.20	0.23	0.26	0.30	0.32	0.33
		4 (N = 62)	0.19	0.24	0.26	0.29	0.32	0.34	0.37
		5 (N = 42)	0.24	0.26	0.29	0.32	0.35	0.37	0.38
		6 (N = 39)	0.29	0.32	0.32	0.34	0.36	0.39	0.43
	Girls	3 (N = 62)	0.18	0.20	0.22	0.26	0.30	0.33	0.34
		4 (N = 61)	0.24	0.27	0.28	0.29	0.32	0.35	0.36
		5 (N = 55)	0.26	0.28	0.29	0.32	0.34	0.37	0.39
		6 (N = 41)	0.26	0.30	0.31	0.35	0.37	0.38	0.40
Height (cm)	Boys	3 (N = 43)	4.06	4.95	6.60	8.05	10.93	12.61	13.23
		4 (N = 62)	4.24	7.13	8.25	10.20	12.30	14.42	16.77
		5 (N = 42)	6.78	8.65	10.05	12.60	14.68	16.65	17.88
		6 (N = 39)	10.34	12.20	12.83	14.35	15.48	18.44	22.31
	Girls	3 (N = 62)	3.82	5.00	5.95	8.00	10.65	13.25	13.89
		4 (N = 61)	7.10	8.80	9.50	10.50	12.60	14.90	15.60
		5 (N = 55)	8.15	9.85	10.38	12.20	13.90	17.05	18.53
		6 (N = 41)	8.48	11.02	11.60	14.70	16.35	18.02	19.33
Power (W/kg)	Boys	3 (N = 43)	4.22	4.71	5.40	6.70	8.56	9.43	10.03
		4 (N = 62)	4.88	6.21	7.33	8.85	10.95	13.92	16.10
		5 (N = 42)	7.14	7.59	8.17	9.50	11.25	13.83	15.60
		6 (N = 39)	7.54	9.07	9.92	11.62	12.62	16.07	17.57
	Girls	3 (N = 62)	4.02	5.03	5.87	7.30	9.06	10.73	12.88
		4 (N = 61)	5.59	7.14	7.69	8.55	10.16	11.87	13.27
		5 (N = 55)	6.45	7.51	8.29	9.66	11.31	14.50	17.64
		6 (N = 41)	6.14	8.38	9.21	11.29	14.72	19.72	21.16
Pace (steps/s)	Boys	3 (N = 43)	0.29	0.34	0.40	0.54	0.68	1.67	2.67
		4 (N = 62)	0.31	0.47	0.53	0.87	1.29	1.93	2.26
		5 (N = 42)	0.25	0.50	0.59	0.80	1.42	2.30	3.24
		6 (N = 39)	0.35	0.56	0.62	0.97	1.80	2.40	4.76
	Girls	3 (N = 62)	0.29	0.41	0.48	0.64	0.99	1.93	2.22
		4 (N = 61)	0.38	0.49	0.55	0.65	0.88	1.57	1.98
		5 (N = 55)	0.36	0.47	0.56	0.70	1.01	1.52	1.74
		6 (N = 41)	0.32	0.52	0.58	0.87	1.45	1.72	1.80
RSI (m/s)	Boys	3 (N = 43)	0.01	0.02	0.03	0.05	0.06	0.13	0.20
		4 (N = 62)	0.02	0.04	0.06	0.10	0.19	0.36	0.47
		5 (N = 42)	0.03	0.06	0.07	0.10	0.20	0.29	0.38
		6 (N = 39)	0.04	0.08	0.10	0.17	0.23	0.45	0.51

Table 3. *Cont.*

Measure	Sex	Age (years)	P5	P15	P25	P50 (M)	P75	P90	P95
RSI (m/s)	Girls	3 (N = 62)	0.02	0.02	0.03	0.06	0.11	0.24	0.31
		4 (N = 61)	0.03	0.05	0.06	0.09	0.10	0.27	0.32
		5 (N = 55)	0.04	0.06	0.07	0.09	0.21	0.31	0.49
		6 (N = 41)	0.04	0.07	0.09	0.17	0.33	0.60	0.65
Verticality	Boys	3 (N = 43)	0.24	0.56	1.04	1.63	3.88	8.65	19.28
		4 (N = 62)	0.34	0.82	1.13	2.51	4.64	10.38	15.57
		5 (N = 42)	0.76	1.35	1.47	3.02	6.33	10.61	13.17
		6 (N = 39)	0.82	1.16	1.41	2.86	5.74	11.94	23.32
	Girls	3 (N = 62)	0.54	0.89	1.51	2.41	4.49	7.59	8.48
		4 (N = 61)	0.62	0.83	1.09	1.92	2.90	7.19	20.13
		5 (N = 55)	0.68	1.12	1.56	2.35	4.40	6.93	7.81
		6 (N = 41)	0.88	1.10	1.62	3.38	4.89	16.37	32.88

Table 4. Normative data for CMJ with arm swing, according to sex and age.

Measure	Sex	Age (years)	P5	P15	P25	P50 (M)	P75	P90	P95
Contact time (s)	Boys	3 (N = 43)	0.72	1.17	1.38	1.63	2.42	3.45	6.35
		4 (N = 62)	0.66	0.92	1.09	1.53	2.11	2.92	3.75
		5 (N = 42)	0.71	0.82	0.98	1.41	1.97	2.75	2.92
		6 (N = 39)	0.40	0.79	1.00	1.33	1.95	2.68	2.94
	Girls	3 (N = 62)	0.71	0.98	1.17	1.70	2.42	3.37	3.72
		4 (N = 61)	0.65	1.03	1.23	1.53	1.95	3.01	3.19
		5 (N = 55)	0.60	0.92	1.08	1.31	1.66	1.95	2.31
		6 (N = 41)	0.42	0.77	0.90	1.29	1.61	2.35	3.33
Flight time (s)	Boys	3 (N = 43)	0.21	0.22	0.24	0.27	0.31	0.33	0.33
		4 (N = 62)	0.21	0.26	0.28	0.32	0.34	0.36	0.39
		5 (N = 42)	0.27	0.31	0.32	0.35	0.37	0.40	0.41
		6 (N = 39)	0.30	0.31	0.32	0.36	0.39	0.42	0.44
	Girls	3 (N = 62)	0.19	0.20	0.23	0.27	0.29	0.34	0.35
		4 (N = 61)	0.24	0.27	0.28	0.30	0.34	0.36	0.37
		5 (N = 55)	0.26	0.30	0.31	0.34	0.37	0.39	0.41
		6 (N = 41)	0.29	0.31	0.33	0.37	0.39	0.43	0.45
Height (cm)	Boys	3 (N = 43)	5.21	6.04	6.98	8.80	11.55	13.20	13.50
		4 (N = 62)	5.54	8.42	9.50	12.20	13.90	16.09	18.80
		5 (N = 42)	8.68	11.60	12.75	14.75	16.68	19.65	20.35
		6 (N = 39)	10.81	11.95	12.65	15.65	18.88	21.55	23.52
	Girls	3 (N = 62)	4.30	5.13	6.60	8.70	10.68	14.25	14.80
		4 (N = 61)	7.10	9.00	9.80	11.20	13.90	16.20	17.00
		5 (N = 55)	7.95	11.00	12.00	13.85	16.63	18.85	20.60
		6 (N = 41)	10.25	11.99	13.70	16.60	18.85	22.38	25.16

Table 4. *Cont.*

Measure	Sex	Age (years)	P5	P15	P25	P50 (M)	P75	P90	P95
Power (W/kg)	Boys	3 (N = 43)	4.17	4.64	5.50	7.03	8.37	9.46	12.04
		4 (N = 62)	5.93	6.74	7.22	8.70	9.88	10.76	13.74
		5 (N = 42)	7.51	8.27	8.80	9.93	11.14	13.37	16.49
		6 (N = 39)	8.02	8.41	8.88	10.87	12.03	13.96	16.66
	Girls	3 (N = 62)	4.28	5.09	6.04	7.12	8.32	9.69	10.89
		4 (N = 61)	5.91	7.03	7.46	8.44	9.61	10.77	14.10
		5 (N = 55)	7.11	8.15	8.67	9.73	11.02	12.38	16.12
		6 (N = 41)	8.45	9.69	9.99	10.78	12.56	14.14	16.77
Pace (steps/s)	Boys	3 (N = 43)	0.15	0.31	0.40	0.58	0.71	1.29	2.01
		4 (N = 62)	0.26	0.38	0.46	0.58	0.77	1.23	2.59
		5 (N = 42)	0.30	0.33	0.46	0.59	0.92	1.23	2.68
		6 (N = 39)	0.31	0.38	0.44	0.60	0.87	1.35	2.13
	Girls	3 (N = 62)	0.26	0.34	0.40	0.57	0.79	1.13	1.75
		4 (N = 61)	0.29	0.45	0.46	0.60	0.87	2.49	3.01
		5 (N = 55)	0.38	0.48	0.53	0.64	0.79	2.55	3.28
		6 (N = 41)	0.27	0.42	0.52	0.61	0.84	1.29	2.45
RSI (m/s)	Boys	3 (N = 43)	0.01	0.02	0.02	0.04	0.07	0.10	0.25
		4 (N = 62)	0.03	0.04	0.05	0.07	0.10	0.14	0.22
		5 (N = 42)	0.04	0.06	0.07	0.10	0.13	0.26	0.40
		6 (N = 39)	0.05	0.07	0.08	0.11	0.16	0.22	0.40
	Girls	3 (N = 62)	0.01	0.02	0.03	0.05	0.07	0.13	0.17
		4 (N = 61)	0.03	0.04	0.05	0.07	0.10	0.18	0.30
		5 (N = 55)	0.05	0.07	0.08	0.10	0.13	0.22	0.35
		6 (N = 41)	0.06	0.07	0.09	0.12	0.16	0.26	0.40
Verticality	Boys	3 (N = 43)	0.27	0.71	0.81	1.46	2.49	4.74	10.23
		4 (N = 62)	0.44	0.69	0.81	1.55	3.62	8.85	13.67
		5 (N = 42)	0.59	0.92	1.38	1.97	3.84	12.90	19.33
		6 (N = 39)	0.64	1.29	1.48	2.73	7.60	19.32	30.03
	Girls	3 (N = 62)	0.31	0.54	0.65	1.43	2.38	5.23	20.90
		4 (N = 61)	0.51	0.70	0.97	2.00	4.80	13.04	26.28
		5 (N = 55)	0.40	0.65	0.88	1.76	3.13	7.60	13.34
		6 (N = 41)	0.76	1.24	1.69	2.39	5.62	24.64	34.84

4. Discussion

The main aim of the present study was to determine normative data for two jumping tests in 3–6-year-old pre-school children. Our findings suggest that there are no differences in CMJ outcomes without and with arm swing between boys and girls, regardless of age, and boys and girls in the same age category perform equally well. However, older boys and girls (observed as a group) scored better jumping parameters on both CMJ tests, compared to their younger peers.

Boys and girls exhibited similar jumping patterns with no obvious differences detectedbetween; this is in line with previous studies on pre-school and early-school children [6,28,29]. At these ages, both boys and girls experience similar hormonal patterns of change, where testosterone levels are still too low to produce sex-related strength changes [30]. Isokinetic knee flexion and extension peak torques and vertical jump height revealed no sex differences in 6-year-old children [6]. Similar findings were reported in a study that found no sex differences in peak torques from knee extension and flexion movements [28]. However, other studies have found pre-school boys to outperform girls in standing broad jump [19], which contradicts our findings. The use of different muscle strength and power tests has been proposed for pre-school children, including a single-joint (isokinetic knee flexion and extension) or multi-joint (CMJ, standing broad jump, Abalakov or Sargent jump test, or leg press) movements compatible with the neuromuscular development of children during this sensitive period [31]. Despite many alternatives for accessing the explosive muscle power of lower limbs, there is still no clear consensus on appropriate tests for assessing physical performance in pre-school children. Even though effort has been made to investigate the reliability and feasibility properties of physical fitness tests [2,32], standing broad jump has been constantly incorporated as a reliable and valid method to assess musculoskeletal fitness, while no evidence for vertical jump has been provided. This is important because the type of test indicates different effect sizes between boys and girls, where the vertical jump result yields no sex differences [6,28], while some studies have reported better outcomes in boys than girls using standing broad jump as a proxy of muscle power [19]. Vertical jump is considered a multi-component action that requires a substantial amount of muscle effort, particularly from ankle, knee, and hip joints. Interestingly, vertical jump was not previously correlated with single-joint movement tests [6], indicating that it should be tested individually from other measures of muscular power. Opposed to vertical jump, evidence suggests that standing broad jump should not be considered an indicator of muscle power in young children, because of their low skill proficiency to extend their arms forward and upward during the take-off phase and downward while landing [33]. Nevertheless, further research is needed to confirm sex differences using a variety of vertical jump outcomes in pre-school children.

This study found that age played a significant role in all vertical jump parameters, which supports previous findings [6,12,19]. In general, an increase in vertical jump height according to age is expected, due to the increase in lower-limb muscle force and more efficient coordination between ankle, knee, and hip joints [34]. Age was positively and moderately correlated with maximum height, flight time, landing, and maximum concentric forces for CMJ with arm swing, while low correlations were presented for CMJ without arm swing [35]. In this study, we found that age correlated strongly with flight time ($r = 0.58$–0.63), jump height ($r = 0.58$–0.63), and power ($r = 0.47$–0.56) for both CMJ with and without arm swing. From a biomechanical perspective, older children tend to move faster and have more joint motions during the take-off and landing phases, generating greater forces [35]. During the first part of the vertical jump movement, the knee and hip need to work simultaneously to promote take-off, while the landing phase of the movement initiates the interplay between knee and ankle for stable foot positioning on the ground [21]. Also, increases in jump height and power in older pre-schoolers results from more effective hip use, higher angular velocity in the take-off phase, and higher ankle range of motion in the landing phase [21]. From a practical point of view, the existing literature highlights the importance of the ‘golden age’ of motor skill development being between the ages of 3 and 6 years [36]. More specifically, there is a rapid increase in locomotor and posture control skills in the first six years of childhood, during which a child needs to learn and practice fundamental motor skills, before plateauing around the age of 8 [37].

International research recommends the use of quintile classification as a standard framework for categorizing general physical fitness [38–41]. Accordingly, individuals are considered to have a very low level of physical fitness below the 20th percentile (p20);

low, from p20 to p40; moderate, from p40 to p60; high, from p60 to p80; and good or very high, above p80 [38,39]. Conversely, some studies indicate that values below the 15th percentile (p15) serve as markers of low physical fitness, requiring timely identification and intervention. Results within the range of p15 to p80 are deemed adequate, whereas values above p85 are interpreted as indicators of a high level of physical fitness [40–42]. The cutoff points applied in this study align with those proposed by authors in previous research (<p15, p15 to p85, and >p85). Children scoring above the >p85 threshold may be considered talented, especially for sports where the assessed ability is relevant, while children below p15 should be more intensively engaged in various types of physical activity.

Finally, we failed to confirm a 'sex*age' interaction, that is, boys and girls in the same age groups exhibited similar values in vertical jumping outcomes. This is not surprising given that we observed no significant sex differences and similar age-related increases in vertical jump parameters. In both sexes, it has been suggested that pre-school children have reduced efficiency during tasks involving the stretch-shortening cycle and lower pre-activation muscle properties [43], limiting their ability to release muscle elastic energy and force transmission [44]. As expected, annual changes dictate similar increases in boys and girls by age, where a critical time period for vertical jump development spurts between ages 3 and 6 [36]. Nevertheless, our findings are in line with previous studies [6,28,29], where 'age' has a large effect on vertical jump changes, while similar observations for pre-school boys and girls are presented. This was confirmed in a longitudinal study where year-to-year progress in vertical jump height was between 10 and 30% in both sexes [29]. However, the same group of authors also showed no significant 'sex*age' interaction [29], reasoning that boys develop a lower rate of force than girls but can produce more force over a longer period of time at a certain age.

The learning and training of vertical jumping significantly contributes to growth, muscle development, and motor learning [45]. Instead of focusing on the effects of interventions, this study emphasizes the quantification of normative data, which is a logical precursor to intervention models. Establishing normative values is a fundamental prerequisite for any further biomechanical analysis, longitudinal monitoring, or diagnostic interpretation, and such reference values are currently lacking in practice.

Although an effort was made to establish normative data for CMJ outcomes in pre-school boys and girls aged 3−6 years, this study is not without limitations. A follow-up design should better examine the natural trend in vertical jump, where an observer could monitor and track 'true' annual changes, rather than follow a cross-sectional design. In line with this, we were unable to conclude a causal relationship between the main effects of 'sex', 'age', and their interaction. However, we obtained similar results, and we speculate that a longitudinal analysis would yield slightly different normative values [29]. Second, we based our data on a relatively small sample size (n = 411) divided into four age and two sex categories, which might have led to a lower statistical power. Third, we were unable to collect further data on children's physical fitness performance or other health-related behaviors, which could serve as potential moderators. Fourth, the sample size for this study was derived from urban areas, where it is expected that children may have more access to playgrounds and other recreational environments, potentially leading to higher physical performance, as opposed to rural kindergarten children. Also, parents of children in urban areas may have higher socioeconomic status, which is important for a variety of extra-curricular and free-time physical activities, including organized sports. Although an effort has been made to create normative data for jumping outcomes in kindergarten children, the data may not be generalizable to children from other socioeconomic backgrounds or ethnic groups, so the findings should be interpreted with caution. Thus, future studies should be taking these limitations into account when creating normative data for vertical jump performance in pre-school children.

5. Conclusions

In summary, the findings of this study show that boys and girls achieve equal values in multiple vertical jump outcomes and that older boys and girls perform better than their younger counterparts. We also observed that boys and girls in the same age categories produced the same effort in all measured tests. Therefore, the effect of 'age' compared to 'sex' is considered the better cross-sectional evaluation predictor of vertical jump parameters in pre-school children.

For a deeper understanding of the relationship between age, sex, and vertical jump performance, future research should employ longitudinal designs with larger and more diverse samples. Such studies would allow for more precise tracking of annual changes and the inclusion of additional variables, such as physical activity levels, physical fitness, and health-related behaviors as potential moderators.

The normative data obtained represent a valuable tool for monitoring and assessing motor development in pre-school-aged children. Professionals, including educators, kinesiologists, and other specialists, can use these data to identify deviations in motor skills and to plan and implement targeted developmental programs. The application of this information enables timely intervention and support during the critical period of motor and overall development in children.

Author Contributions: Conceptualization, V.P. and S.L.; methodology, V.P. and D.N.; software, D.N., V.P. and S.L.; validation, D.N., V.P. and S.L.; formal analysis, V.P., S.L. and D.N.; investigation, V.P. and S.L.; resources, V.P., S.L. and D.N.; data curation, V.P.; writing—original draft preparation, V.P., S.L. and D.N.; writing—review and editing, V.P.; visualization, V.P. and S.L.; supervision, D.N.; project administration, V.P.; funding acquisition, V.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the University of Rijeka as part of the project's morphological analysis of the evolutionary structure of children's bodies (uniri-mladi-drustv-23-37) and biological variations in the motor patterns of early- and pre-school children (uniri-iskusni-drustv-23-201).

Institutional Review Board Statement: As the research involved human subjects, the study was conducted in compliance with all relevant national regulations and institutional policies, in accordance with the tenets of the Helsinki Declaration, and with approval from the Faculty of Teacher Education, University of Rijeka (Morphological Analysis of the Evolutionary Structure of Children's Bodies; uniri-mladi-drustv-23-37; KLASA: 641-01/25-01/O1; URBROJ: 2170-1-38-03-25-4; ln Rijeka, 17 March 2025; Biological Variations in Motor Patterns of Early and Pre-School Children; uniri-iskusni-drustv-23-201; KLASA: 641-01/25-01/01; URBROJ: 2170-138-03-25-3, ln Rijeka, 17 March 2025).

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

Data Availability Statement: The original contributions of the data analyzed in this study are included in this article. Inquiries regarding these data or the raw data can be directed to the corresponding author.

Acknowledgments: We would like to thank all participants for their enthusiastic participation in this study.

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

References

1. True, L.; Pfeiffer, K.A.; Dowda, M.; Williams, H.G.; Brown, W.H.; O'Neill, J.R.; Pate, R.R. Motor competence and characteristics within the preschool environment. *J. Sci. Med. Sport* **2017**, *20*, 751–755. [CrossRef] [PubMed]
2. Ortega, F.B.; Cadenas-Sánchez, C.; Sánchez-Delgado, G.; Mora-González, J.; Martínez-Téllez, B.; Artero, E.G.; Castro-Piñero, J.; Labayen, I.; Chillón, P.; Löf, M.; et al. Systematic review and proposal of a field-based physical fitness-test battery in preschool children: The PREFIT battery. *Sports Med.* **2015**, *45*, 533–555. [CrossRef] [PubMed]
3. Payne, V.G.; Isaacs, L.D. *Human Motor Development: A Lifespan Approach*, 9th ed.; Routledge: Oxford, UK, 2017.
4. Haibach, P.S.; Reid, G.; Collier, D.H. *Motor Learning and Development*, 1st ed.; Human Kinetics: Champaign, IL, USA, 2011.
5. Zhao, P.; Ji, Z.; Wen, R.; Li, J.; Liang, X.; Jiang, G. Biomechanical characteristics of vertical jumping of preschool children in China based on motion capture and simulation modeling. *Sensors* **2021**, *21*, 8376. [CrossRef] [PubMed]
6. Lundgren, S.S.; Nilsson, J.Å.; Ringsberg, K.A.; Karlsson, M.K. Normative data for tests of neuromuscular performance and DXA-derived lean body mass and fat mass in pre-pubertal children. *Acta Paediatr.* **2011**, *100*, 1359–1367. [CrossRef]
7. Bobbert, M.F.; Casius, L.J. Is the effect of a countermovement on jump height due to active state development? *Med. Sci. Sports Exerc.* **2005**, *37*, 440–446. [CrossRef]
8. Karatrantou, K.; Gerodimos, V.; Voutselas, V.; Manouras, N.; Famisis, K.; Ioakimidis, P. Can sport-specific training affect vertical jumping ability during puberty? *Biol. Sport* **2019**, *36*, 217–224. [CrossRef]
9. Alvero-Cruz, J.R.; Brikis, M.; Chilibeck, P.; Frings-Meuthen, P.; Vico Guzmán, J.F.; Mittag, U.; Michely, S.; Mulder, E.; Tanaka, H.; Tank, J.; et al. Age-related decline in vertical jumping performance in masters track and field athletes: Concomitant influence of body composition. *Front. Physiol.* **2021**, *12*, 643649. [CrossRef]
10. Watkins, C.M.; Barillas, S.R.; Wong, M.A.; Archer, D.C.; Dobbs, I.J.; Lockie, R.G.; Coburn, J.W.; Tran, T.T.; Brown, L.E. Determination of vertical jump as a measure of neuromuscular readiness and fatigue. *J. Strength Cond. Res.* **2017**, *31*, 3305–3310. [CrossRef]
11. Seefeldt, V. Physical fitness in preschool and elementary school-aged children. *Am. Phys. Educ. Rev.* **1984**, *55*, 33–40. [CrossRef]
12. Walters, G.W.M.; Cooper, S.; Carlevaro, F.; Magno, F.; Boat, R.; Vagnetti, R.; D'Anna, C.; Musella, G.; Magistro, D. Normative percentile values for the TGMD-3 for Italian children aged 3–11+years. *J. Sci. Med. Sport* **2024**, *28*, 398–407. [CrossRef]
13. Taylor, M.J.; Cohen, D.; Voss, C.; Sandercock, G.R. Vertical jumping and leg power normative data for English school children aged 10–15 years. *J. Sports Sci.* **2010**, *28*, 867–872. [CrossRef] [PubMed]
14. Payne, N.; Gledhill, N.; Katzmarzyk, P.T.; Jamnik, V.K.; Keir, P.J. Canadian musculoskeletal fitness norms. *Can J. Appl. Physiol.* **2000**, *25*, 430–442. [CrossRef] [PubMed]
15. He, H.; Pan, L.; Wang, D.; Du, J.; Pa, L.; Wang, H.; Zhao, J.; Peng, X.; Shan, G. The normative values of vertical jump and sit-and-reach in a large general Chinese population aged 8–80 years: The China National Health Survey. *Glob. Transit.* **2023**, *5*, 141–148. [CrossRef]
16. Gantiraga, E.; Katartzi, E.; Komsis, G.; Papadopoulos, C. Strength and vertical jumping performance characteristics in school-aged boys and girls. *Biol. Sport* **2006**, *23*, 367.
17. Calero-Morales, S.; Villavicencio-Alvarez, V.E.; Flores-Abad, E.; Monroy-Antón, A.J. Pedagogical control scales of vertical jumping performance in untrained adolescents (13–16 years): Research by strata. *PeerJ* **2024**, *12*, e17298. [CrossRef]
18. Ramírez-Vélez, R.; Correa-Bautista, J.E.; Lobelo, F.; Cadore, E.L.; Alonso-Martinez, A.M.; Izquierdo, M. Vertical jump and leg power normative data for Colombian schoolchildren aged 9–17.9 years: The FUPRECOL study. *J. Strength Cond. Res.* **2017**, *31*, 990–998. [CrossRef] [PubMed]
19. Yip, K.M.; So, H.K.; Tung, K.T.S.; Wong, R.S.; Tso, W.W.Y.; Wong, I.C.K.; Yam, J.C.; Kwan, M.Y.W.; Louie, L.H.T.; Lee, A.; et al. Normative values of motor performance and their relationship with BMI status in Hong Kong preschoolers. *Sci. Rep.* **2024**, *14*, 6567. [CrossRef]
20. Harsted, S.; Hestbaek, L.; Holsgaard-Larsen, A.; Hein Lauridsen, H. Dynamic lower limb alignment during jumping in preschool children: Normative profiles and sex differences. *J. Mot. Learn. Dev.* **2023**, *12*, 68–89. [CrossRef]
21. Raffalt, P.C.; Alkjaer, T.; Simonsen, E.B. Intra-subject variability in muscle activity and co-contraction during jumps and landings in children and adults. *Scand. J. Med. Sci. Sports* **2017**, *27*, 820–831. [CrossRef] [PubMed]
22. Payne, G.; Peixin, G.; Guoli, L. *Introduction to Human Motor Development*; People's Education Press: Beijing, China, 2008.
23. Glatthorn, J.F.; Gouge, S.; Nussbaumer, S.; Stauffacher, S.; Impellizzeri, F.M.; Maffiuletti, N.A. Validity and reliability of Optojump photoelectric cells for estimating vertical jump height. *J. Strength Cond. Res.* **2011**, *25*, 556–560. [CrossRef] [PubMed]
24. Bosco, C.; Luhtanen, P.; Komi, P.V. A simple method for measurement of mechanical power in jumping. *Eur. J. Appl. Physiol. Occup. Physiol.* **1983**, *50*, 273–282. [CrossRef]
25. Bogataj, Š.; Pajek, M.; Hadžić, V.; Andrašić, S.; Padulo, J.; Trajković, N. Validity, reliability, and usefulness of My Jump 2 App for measuring vertical jump in primary school children. *Int. J. Environ. Res. Public Health* **2020**, *17*, 3708. [CrossRef]
26. Healy, R.; Kenny, I.C.; Harrison, A.J. Assessing reactive strength measures in jumping and hopping using the Optojump™ system. *J. Hum. Kinet.* **2016**, *54*, 23–32. [CrossRef] [PubMed]

27. Holm, I.; Fredriksen, P.; Fosdahl, M.; Vollestad, N. A normative sample of isotonic and isokinetic muscle strength measurements in children 7 to 12 years of age. *Acta Paediatr.* **2008**, *97*, 602–607. [CrossRef] [PubMed]
28. Koren, K.; Pisot, R.; Simunic, B. Vertical jump height in young children—A longitudinal study in 4- to 6-year old children. *Ann. Kinesiol.* **2016**, *7*, 153–170.
29. Fry, A.C.; Irwin, C.C.; Nicoll, J.X.; Ferebee, D.E. Muscular strength and power in 3-to 7-year-old children. *Pediatr. Exerc. Sci.* **2015**, *27*, 345–354. [CrossRef]
30. Harman, E.A.; Rosenstein, M.T.; Frykman, P.N.; Rosenstein, R.M.; Kramer, W.J. Estimates of human power output from vertical jump. *J. Appl. Sport Sci. Res.* **1991**, *5*, 116–120.
31. Cadenas-Sanchez, C.; Martinez-Tellez, B.; Sanchez-Delgado, G.; Mora-Gonzalez, J.; Castro-Piñero, J.; Löf, M.; Ruiz, J.R.; Ortega, F.B. Assessing physical fitness in preschool children: Feasibility, reliability and practical recommendations for the PREFIT battery. *J. Sci. Med. Sport* **2016**, *19*, 910–915. [CrossRef]
32. Duncan, M.J.; Roscoe, C.M.; Noon, M.; Clark, C.C.; O'Brien, W.; Eyre, E.L. Run, jump, throw and catch: How proficient are children attending English schools at the fundamental motor skills identified as key within the school curriculum? *Eur. Phys. Educ. Rev.* **2020**, *26*, 814–826. [CrossRef]
33. Harrison, A.J.; Gaffney, S. Motor development and gender effects on stretch-shortening cycle performance. *J. Sci. Med. Sport* **2021**, *4*, 406–415. [CrossRef]
34. Harrison, A.J.; Ryan, W.; Hayes, K. Functional data analysis of joint coordination in the development of vertical jump performance. *Sports Biomech.* **2007**, *6*, 199–214. [CrossRef] [PubMed]
35. Gieysztor, E.; Dawidziak, A.; Kowal, M.; Paprocka-Borowicz, M. Jumping Motor Skills in Typically Developing Preschool Children Assessed Using a Battery of Tests. *Sensors* **2024**, *24*, 1344. [CrossRef]
36. Wang, H.; Chen, Y.; Liu, J.; Sun, H.; Gao, W. A follow-up study of motor skill development and its determinants in preschool children from middle-income family. *BioMed Res. Int.* **2020**, *2020*, 6639341. [CrossRef]
37. Bolger, L.E.; Bolger, L.A.; O'Neill, C.; Coughlan, E.; O'Brien, W.; Lacey, S.; Burns, C.; Bardid, F. Global levels of fundamental motor skills in children: A systematic review. *J. Sports Sci.* **2021**, *39*, 717–753. [CrossRef] [PubMed]
38. Catley, M.J.; Tomkinson, G.R. Normative healthrelated fitness values for children: Analysis of 85347 test results on 9–17-year-old Australians since 1985. *Br. J. Sports Med.* **2013**, *47*, 98–108. [CrossRef]
39. Ortega, F.B.; Artero, E.G.; Ruiz, J.R.; España-Romero, V.; Jiménez-Pavón, D.; Vicente-Rodríguez, G.; Moreno, L.A.; Manios, Y.; Béghin, L.; Ottevaere, C.; et al. Physical fitness levels among European adolescents: The HELENA study. *Br. J. Sports Med.* **2011**, *45*, 20–29. [CrossRef]
40. World Medical Association. World Medical Association Declaration of Helsinki: Ethical principles for medical research involving human subjects. *JAMA* **2013**, *310*, 2191–2194. [CrossRef]
41. Gómez-Campos, R.; Andruske, C.L.; De Arruda, M.; Sulla-Torres, J.; Pacheco-Carrillo, J.; Urra-Albornoz, C.; Cossio-Bolaños, M. Normative data for handgrip strength in children and adolescents in the Maule Region, Chile: Evaluation based on chronological and biological age. *PLoS ONE* **2018**, *13*, e0201033. [CrossRef]
42. Hobold, E.; Pires-Lopes, V.; Gómez-Campos, R.; De Arruda, M.; Andruske, C.L.; Pacheco-Carrillo, J.; Cossio-Bolaños, M.A. Reference standards to assess physical fitness of children and adolescents of Brazil: An approach to the students of the Lake Itaipú region—Brazil. *PeerJ* **2017**, *5*, e4032. [CrossRef]
43. Gomez-Campos, R.; Vidal-Espinoza, R.; Castelli Correia de Campos, L.F.; Andruske, C.L.; Sulla-Torres, J.; Urra-Albornoz, C.; Cossio-Bolaños, W.; Alvear-Vasquez, F.; Mendez-Cornejo, J.; Cossio-Bolaños, M. Regulation data for the horizontal jump of children and adolescents. *Eur. J. Transl. Myol.* **2021**, *31*, 9461. [CrossRef] [PubMed]
44. Kubo, K.; Kanehisa, H.; Kawakami, Y.; Fukanaga, T. Growth changes in the elastic properties of human tendon structures. *Int. J. Sports Med.* **2001**, *22*, 138–143. [CrossRef] [PubMed]
45. Liu, L.; Xi, L.; Yongshun, W.; Ziping, Z.; Chunyin, M.; Peifu, Q. More Jump More Health: Vertical Jumping Learning of Chinese Children and Health Promotion. *Front. Psychiatry* **2022**, *13*, 885012. [CrossRef] [PubMed]