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Identifying the Differences in Symmetry of the Anthropometric Parameters of the Upper Limbs in Relation to Manual Laterality between Athletes Who Practice Sports with and without a Ball

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Abstract: The purpose of this study was to identify the asymmetries between the dimensions of the upper limbs, in relation to manual laterality, of the athletes who practice team sports with a ball and those who practice other sports without a ball. We consider the fact that ball handling influences the development of anthropometric parameters at the level of the upper limbs and especially at the level of the hand in correlation with the execution technique and with the characteristics of the practiced sport. This study included 161 student-athletes, who were male and right-handed, divided into two groups: the group of athletes practicing ball sports (G_BS) with 79 (49%) subjects and the group of athletes practicing non-ball sports (G_NBS) with 82 (51%) subjects. The anthropometric measurements of the upper limbs were performed on both sides (right and left): upper limb length, hand length, palm length, hand breadth, hand span, pinky finger, ring finger, middle finger, index finger and thumb. The most relevant symmetries, between the two groups, were recorded in the following anthropometric parameters on the right side (recording the smallest average differences): ring finger 0.412 cm and thumb 0.526 cm; for the left side, they were the ring finger 0.379 cm and thumb 0.518 cm. The biggest asymmetries between the two groups were recorded, for both the right and left sides, for the following parameters: upper limb length > 6 cm; hand span > 2 cm; and hand length > 1 cm. For all the anthropometric parameters analyzed, the athletes from the ball sports group (G_BS) recorded higher average values than those from the other group (G_NBS) for both upper limbs. The results of this study reflect the fact that handling the ball over a long period of time, starting from the beginning of practicing the sport until the age of seniority, causes changes in the anthropometric dimensions of the upper segments, causing asymmetries between the dominant (right) and the non-dominant (left) side.

Keywords: anthropometric asymmetries; sports with ball; sports without ball; right and left upper limbs; longitudinal and transversal dimensions; human body symmetry

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1. Introduction

1.1. General Information about Asymmetries in Sports

Recent research focuses on the identification of symmetry and proportional relationships between different anthropometric body parameters [1–3]. A series of studies have highlighted numerous minor asymmetries between different human anthropometric parameters, comparing the morphological development of the right and left side of the body [4,5]. Sports performance is influenced by the individual characteristics of physical development and by the level of the motor and technical ability of athletes in relation to the specifics of the sport practiced [6,7]. Somatic growth and development are influenced by endogenous and exogenous factors embodied by the following aspects: genetic, morphological, endocrine, metabolic, environmental, physical activity level, nutritional, quality of life, etc. [8,9]. Studies have highlighted the impact of physical exercise on physical growth and development in different stages of ontogeny [10,11]. The diversification of the forms of physical exercise and the modernization of sports equipment and technologies required the adaptation of the training process with an impact on the physical development of the practitioners [12,13]. Studies have shown that perceptual asymmetries are beneficial (as is the case of eye acuity for shooting), as well as the development of some anthropometric dimensions of the upper and lower limbs that are the result of a long process of preparation in relation to the sport practiced and involves mainly unilateral executions in the regime of force, speed and coordination [1,2,14,15]. In these cases, the dominant segment develops asymmetrically compared to the non-dominant one, and this fact, on the one hand, can facilitate the efficiency of some technical exercises, but on the other hand, it can cause the appearance of musculoskeletal disorders and negative influences on mobility, technique, aesthetics and body postures [16,17].

1.2. Specific Information on Asymmetries in Sports That Involve the Use and Non-Use of Implements with the Hands

Sports that use objects, such as a ball, require the athletes to adapt both to the specifics of the sport and the effort, as well as to the dimensions and characteristics of the ball or the equipment used [18–20]. The technical skills specific to team games with a ball such as catching, passing, throwing, etc., determine the adaptation of the way the ball is held or handled with one or both hands, as well as the characteristics and different sizes of the ball [21]. These adaptations require, from the players, a certain arrangement of the palms and fingers on the ball in relation to the dimensions of the ball and the execution technique. Prolonged sports training for handling the ball can influence how the transverse or longitudinal dimensions of the hand develop [22,23]. A series of studies have highlighted asymmetries in the development of anthropometric parameters between the dominant and the non-dominant hand [21,24]. Other studies have focused on identifying the differences in the anthropometric parameters of the upper and lower limbs according to different age categories or gender [25–27].

The specificity of the practiced sport requires the adaptation of the preparation and the adaptation of the technical executions depending on the object of the game. In the case of sports games, the size of the ball is adapted to the age characteristics of the athletes, with the ball being of different sizes depending on the sports category (the size and weight of the ball increases in relation to the age of the players). Perfecting technical skills requires efficient handling of the ball, regarding catching, holding, passing, throwing, etc. Adapting to the characteristics of the ball, we consider that it influences the level of development of the dimensions of the upper limbs, especially at the level of the palm.

1.3. Statement of the Problem, Where the Problematic Situation Is Clearly Identified and the Importance of this Study Is Justified

Numerous studies aimed at measuring the anthropometric dimensions of athletes in relation to the practiced sport [10,28,29], but studies that identify how the specific sports training for team games with a ball influences the level of development of the ball are extremely few in number; we have not identified a specialized study on this topic. We consider that the long training time interval from children, juniors and seniors in which the technical executions of players from team sports with a ball required continuous adaptation to the characteristics of the ball. The long sports training with a ball determines the development and adaptation of certain anthropometric parameters of the hand to the dimensions and characteristics of the ball and to the playing technique. Based on the previously presented arguments, we consider that the novel aspects of our study consist of the identification of symmetries and asymmetries between the anthropometric parameters of the right and left upper limbs of athletes who practice sports with a ball compared to those who practice sports without a ball.

Asymmetry of the upper limbs can determine symmetries of the posture of the whole body [30,31]. The asymmetry of the upper limbs and the hand can have an influence on the structure of the body involving muscles, joints, tendons, ligaments, nerves, bones, the circulatory system, etc. [32,33]. Also, the asymmetries of the upper limbs and the hand can have a major impact on subjects regarding body aesthetics [34,35]. In athletes, the inequalities of the longitudinal and transversal anthropometric dimensions of the upper limb combined with the preponderant involvement of the dominant segment in handling the ball can cause the appearance of some medical conditions. Studies have shown that in athletes, the most common diseases of the upper limbs appear as a result of long repetitive demands, among which we have identified sprains or strains, carpal tunnel syndrome, tendinitis and white finger syndrome (Raynaud's syndrome) [36–38]. Prolonged handling of the ball mainly with the dominant upper segment influences the upper development of motor parameters, such as strength, joint mobility, coordination, etc. [39–41]. The anthropometric evaluation of the upper limbs and the hand allows for the identification of asymmetries in order to correct them through physical therapy exercises and by preventing the risk of accidents [42–44]. The identification and correction of the asymmetries of the upper limbs and the hand contribute to maximizing the motor potential of the athletes [45,46].

1.4. Objectives of this Study and Hypotheses

The aim of this study was to identify the asymmetries between the dimensions of the upper limbs, in relation to manual laterality, of the athletes who practice team sports with a ball and those who practice other sports without a ball. The hypothesis of this study was based on the assumption that athletes who practice team sports with a ball, compared to those who practice other sports without a ball, have asymmetries of the upper limbs, in relation to manual laterality, as a result of handling the ball for a long time.

2. Materials and Methods

2.1. Participants

The present cross-sectional study included 161 student-athletes, who were male and right-handed (dominant hand), divided into two groups: the group of athletes practicing ball sports (G_BS) with 79 (49%) subjects and the group of athletes practicing non-ball sports (G_NBS) with 82 (51%) subjects. The characteristics of the group of athletes practicing ball sports (G_BS) included the following: age (arithmetic mean $\pm$ SD), 20.73 $\pm$ 1.32 years; height, 1.83 $\pm$ 0.05 cm; and coefficient of variation (CV) 3.22%, minimum 170 cm and maximum 192 cm. The characteristics of the group of athletes practicing non-ball sports (G_NBS) included the following: age (arithmetic mean $\pm$ SD), 20.91 $\pm$ 1.18 years; height, 1.79 $\pm$ 0.06 cm; and coefficient of variation (CV) 3.35%, minimum 169 cm and maximum 188 cm. The subjects of the G_BS are active athletes from the following team games (with the ball): handball 68 (73.4%) and basketball 21 (26.6%). The subjects of the G_NBS are active athletes from the following sports (without a ball): athletics, swimming, sports dance, karate and gymnastics. The sample size calculated for this study was 148 subjects for a confidence level of 95%, with a margin of error $\pm$5%. In this study, initially 165 subjects were included. We kept 161 subjects, and 4 subjects were eliminated because it was found that they had injuries on a hand and could not perform anthropometric measurements under the specific conditions of this study. The inclusion criteria of the subjects in this study include active athletes, students in the bachelor's and master's program in the field of physical education and sports, performance of all anthropometric measurements, and age 20–24 years. The subjects of this study participated voluntarily on the basis of an informed consensus regarding compliance with the principles of the Declaration of Helsinki. This study was approved, no. 11.1./11 April 2023, by the Review Board of the Physical Education and Sports Program of "G.E. Palade" University of Medicine, Pharmacy, Science and Technology of Targu Mures, Romania.

2.2. Study Design

This study took place between November and December 2023, aiming to measure the anthropometric parameters of the upper limbs of the study subjects (Figure 1). The anthropometric measurement sessions were carried out under similar conditions and with the same measuring instruments for all the subjects in the two groups. The order of the anthropometric measurements was identical for all the subjects. The anthropometric measurements of the upper limbs were performed on both sides of the body (right and left): upper limb length, hand length, palm length, hand breadth, hand span, pinky finger, ring finger, middle finger, index finger and thumb. The height measurement was performed with a digital height measuring scale, and the measurement of the anthropometric dimensions of the hands was performed with a digital caliper. The collection of anthropometric data of the subjects of this study was carried out by the authors in the same institutions and using the same equipment.

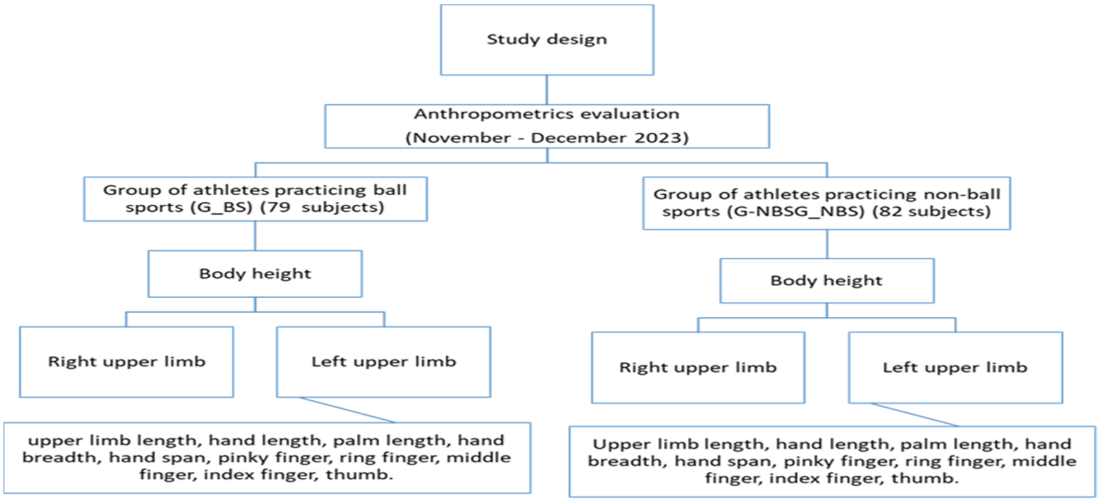

Figure 1. Study design.

2.3. Measures

The 11 anthropometric parameters measured for this study were as follows (Figure 2):

- Height—the distance between the vertex and the level of the sole (support surface) in the orthostatic position.
- Upper limb length—the distance between the acromion and the dactylion in the orthostatic position with the upper limb in maximum extension.
- Hand length—the distance between the styloid line and the dactylion.
- Palm length—the distance between the styloid line and the proximal phalanges between the middle and ring finger.
- Hand breadth—the direct distance from the most lateral point on the head of the second metacarpal to the most medial point on the head of the fifth metacarpal.
- Hand span—the distance between the proximal phalanges of the pinky finger and the distal phalanges of the thumb, with the fingers being brought to the maximum angles.
- Pinky finger—the distance between the proximal phalanges and distal phalanges of the pinky finger.
- Ring finger—the distance between the proximal phalanges and distal phalanges of the ring finger.
- Middle finger—the distance between the proximal phalanges and distal phalanges of the middle finger.
- Index finger—the distance between the proximal phalanges and distal phalanges of the index finger.
- Thumb—the distance between the proximal phalanges and distal phalanges of the thumb.

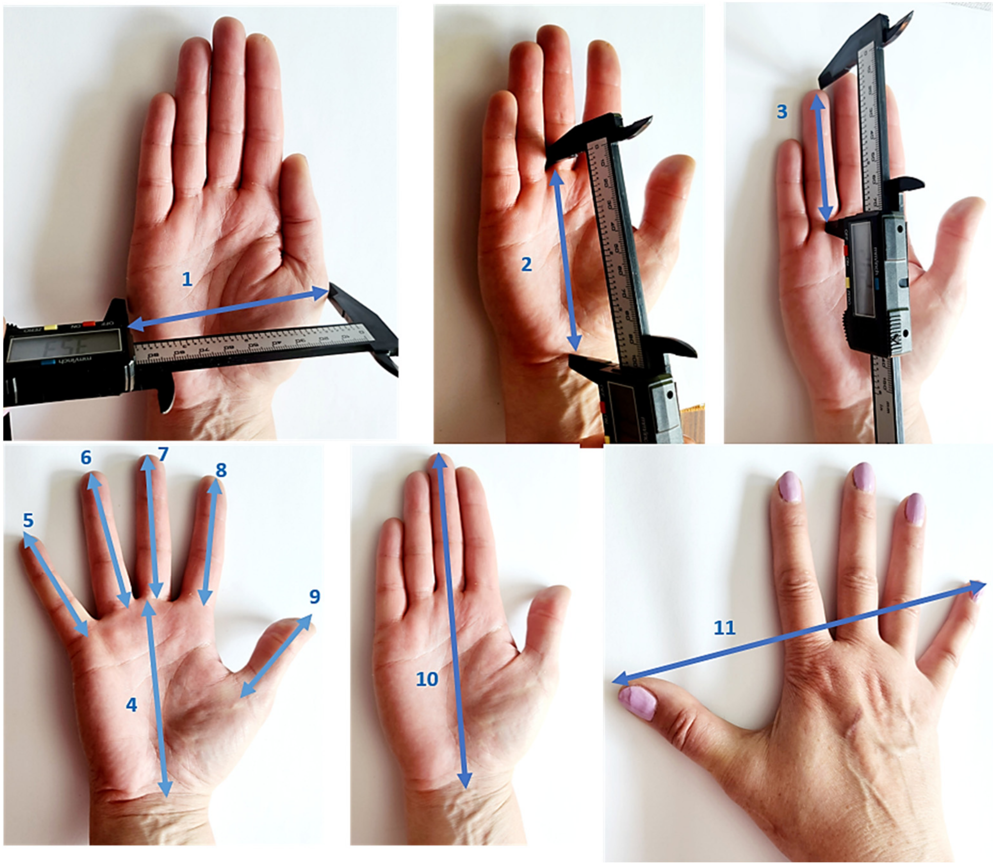

Figure 2. Hand anthropometrics (1. hand breadth, 2./4. palm length, 5. pinky finger, 6. ring finger, 3/7. middle finger, 8. index finger, 9. thumb, 10. hand length and 11. hand span).

2.4. Statistical Analysis

The results of this study were processed statistically with the IBM-SPSS 22 software. To highlight the relevance of the results, we calculated the following statistical parameters: the average (X); standard deviation (SD); mean difference between the final and initial tests (ΔX); Std. Error Difference (SED); Fisher test value (F); Student T-test (t); coefficient of variance for the homogeneity of the group (CV); and the confidence interval with lower and upper levels (95% CI). The reference value selected for statistical significance was $p < 0.05$.

The standardized Limb Symmetry Index (SI) and the standardized directional asymmetry (DA) were calculated for all the anthropometric parameters targeted in this study. The DA score is a qualitative indicator that indicates the direction of asymmetry of the anthropometric parameters toward the right and the left (a positive value indicates the right side, and a negative value indicates that the left side has higher values).

The calculation formulas were as follows [41,47,48]:

$$SI = ((X\_\mathit{Right}\text{ upper limb} - X\_\mathit{Left}\text{ upper limb})/0.5 \times (X\_\mathit{Right}\text{ upper limb} - X\_\mathit{Left}\text{ upper limb})) \times 100$$

$$DA = ((X\_\mathit{Right}\text{ upper limb} - X\_\mathit{Left}\text{ upper limb})/(X\_\mathit{Right}\text{ upper limb} + X\_\mathit{Left}\text{ upper limb})) \times 100$$

3. Results

Table 1 shows the results recorded by the two groups in this study regarding the anthropometric parameters of the right and left upper limbs. In Table 2, we present the comparative results recorded between the right and left upper segments for each group in this study; in Table 3, we show the comparative results between the two groups in this study. In Table 4, we present the results of the asymmetry and asymmetry indexes of the anthropometrics parameters between the right and left upper limbs.

Table 1. Descriptive statistics of the anthropometric measurements of the upper limbs of the group practicing non-ball sports (G_NBS) and the group practicing ball sports (G_BS).

Parameters	Group	Side	Minimum	Maximum	X	SD	Variance	Kurtosis	CV (%)
Upper limb length	G_NBS	Right	69.00	79.00	74.004	3.141	9.867	−1.110	4.24
		Left	68.00	80.00	74.071	3.296	10.867	−0.766	4.45
	G_BS	Right	74.00	86.00	80.063	3.569	12.740	−1.014	4.46
		Left	74.00	87.00	80.317	3.941	15.533	−0.999	4.91
Hand length	G_NBS	Right	17.10	21.60	18.509	1.298	1.686	0.538	7.01
		Left	17.00	21.50	18.449	1.167	1.362	1.258	6.33
	G_BS	Right	18.00	21.50	19.579	1.178	1.387	−1.436	6.02
		Left	18.00	21.60	19.525	1.138	1.296	−1.402	5.83
Palm length	G_NBS	Right	9.60	12.00	10.976	0.741	0.549	−0.872	6.75
		Left	9.50	12.100	11.000	0.766	0.586	−0.945	6.96
	G_BS	Right	11.00	13.00	11.880	0.653	0.427	−0.920	5.50
		Left	11.10	13.10	11.854	0.638	0.407	−0.706	5.38
Hand breadth	G_NBS	Right	6.80	9.00	7.759	0.724	0.525	−1.293	9.33
		Left	6.70	9.10	7.754	0.730	0.533	−1.274	9.41
	G_BS	Right	7.10	9.50	8.372	0.666	0.444	−0.731	7.96
		Left	7.20	9.50	8.371	0.656	0.430	−0.623	7.84
Hand span	G_NBS	Right	18.00	22.00	19.842	1.205	1.452	−0.815	6.07
		Left	18.00	22.50	19.878	1.276	1.629	−0.502	6.42
	G_BS	Right	20.00	25.50	22.171	1.738	3.022	−1.050	7.84
		Left	20.10	25.00	22.172	1.688	2.850	−0.989	7.61
Pinky finger	G_NBS	Right	5.10	6.40	5.589	0.360	0.129	0.116	6.44
		Left	5.20	6.50	5.592	0.378	0.143	0.209	6.76
	G_BS	Right	5.50	7.00	6.263	0.439	0.193	−1.091	7.01
		Left	5.60	7.20	6.223	0.462	0.213	−0.644	7.42
Ring finger	G_NBS	Right	6.10	7.80	7.111	0.491	0.241	−0.783	6.90
		Left	6.20	7.90	7.124	0.491	0.241	−0.995	6.89
	G_BS	Right	6.50	8.10	7.523	0.452	0.205	−0.198	6.01
		Left	6.60	8.20	7.504	0.447	0.200	−0.218	5.96
Middle finger	G_NBS	Right	6.60	8.30	7.348	0.471	0.222	−0.884	6.41
		Left	6.80	8.20	7.356	0.436	0.190	−0.689	5.93
	G_BS	Right	7.20	8.80	8.056	0.505	0.255	−1.090	6.27
		Left	7.10	8.80	8.029	0.496	0.246	−0.735	6.18
Index finger	G_NBS	Right	6.20	7.50	6.738	0.388	0.150	−0.804	5.76
		Left	6.20	7.60	6.740	0.365	0.134	0.097	5.42
	G_BS	Right	6.60	8.10	7.322	0.473	0.224	−1.043	6.46
		Left	6.50	8.00	7.300	0.457	0.209	−1.065	6.26
Thumb	G_NBS	Right	4.80	6.50	5.422	0.369	0.136	1.779	6.81
		Left	4.70	6.60	5.401	0.353	0.125	2.842	6.54
	G_BS	Right	5.40	6.70	5.948	0.403	0.163	−1.127	6.78
		Left	5.30	6.60	5..919	0.414	0.171	−1.398	6.99

X—mean; SD—standard deviation; and CV—coefficient of variance.

Table 2. Statistical analysis of the anthropometric measurements of the upper limbs of the group practicing non-ball sports (G_NBS) and the group practicing ball sports (G_BS).

Parameters	Group	Side	Mean	SD	ΔX	SD	95% CI		t	*p*
							Lower	Upper		
Upper limb length	G_NBS	Right	74.004	3.141	−0.067	0.406	−0.156	0.022	−1.498	0.138
		Left	74.071	3.296						
	G_BS	Right	80.063	3.569	−0.253	0.524	−0.371	−0.136	−4.292	<0.001
		Left	80.317	3.941						
Hand length	G_NBS	Right	18.509	1.298	0.060	0.321	−0.011	0.130	1.685	0.096
		Left	18.449	1.167						
	G_BS	Right	19.579	1.138	0.053	0.212	0.006	0.101	2.232	0.028
		Left	19.525	0.653						
Palm length	G_NBS	Right	10.976	0.741	−0.024	0.108	−0.048	−0.001	−2.038	0.045
		Left	11.000	0.766						
	G_BS	Right	11.880	0.653	0.025	0.110	0.001	0.050	2.040	0.045
		Left	11.854	0.638						
Hand breadth	G_NBS	Right	7.759	0.724	0.005	0.038	−0.004	0.013	1.157	0.251
		Left	7.754	0.730						
	G_BS	Right	8.372	0.666	0.001	0.038	−0.007	0.010	0.300	0.765
		Left	8.371	0.656						
Hand span	G_NBS	Right	19.842	1.205	−0.037	0.131	−0.065	−0.008	−2.529	0.113
		Left	19.878	1.276						
	G_BS	Right	22.171	1.738	−0.001	0.164	−0.038	0.036	−0.068	0.946
		Left	22.172	1.688						
Pinky finger	G_NBS	Right	5.589	0.360	−0.002	0.035	−0.010	0.005	−0.630	0.530
		Left	5.592	0.378						
	G_BS	Right	6.263	0.439	0.041	0.094	0.019	0.062	3.827	<0.001
		Left	6.223	0.462						
Ring finger	G_NBS	Right	7.111	0.491	−0.013	0.056	−0.026	−0.001	−2.164	0.033
		Left	7.124	0.491						
	G_BS	Right	7.523	0.452	0.019	0.072	0.003	0.035	2.352	0.021
		Left	7.504	0.447						
Middle finger	G_NBS	Right	7.348	0.471	−0.009	0.093	−0.029	0.012	−0.829	0.409
		Left	7.356	0.436						
	G_BS	Right	8.056	0.505	0.027	0.090	0.006	0.047	2.620	0.011
		Left	8.029	0.496						
Index finger	G_NBS	Right	6.738	0.388	−0.002	0.082	−0.020	0.015	−0.271	0.787
		Left	6.740	0.365						
	G_BS	Right	7.322	0.473	0.022	0.055	0.009	0.034	3.496	0.001
		Left	7.300	0.457						
Thumb	G_NBS	Right	5.422	0.369	0.021	0.073	0.005	0.037	2.562	0.012
		Left	5.401	0.353						
	G_BS	Right	5.948	0.403	0.029	0.072	0.013	0.045	3.600	0.001
		Left	5.919	0.414						

ΔX—mean differences; SD—standard deviation; CI—interval of confidence; t—value of student T-test; and *p*—Sig. level (2-tailed).

Table 3. Independent T-test of the anthropometric parameters of the upper limbs between the two study groups.

Parameters	Groups	Side	F	*p*(F)	t	*p*(t)	ΔX	SED	95% CI	
									Lower	Upper
Upper limb length	G_BS-G_NBS	Right	1.944	0.165	11.447	<0.001	6.060	0.529	5.014	7.105
	G_BS-G_NBS	Left	3.981	0.048	10.923	<0.001	6.246	0.572	5.116	7.375
Hand length	G_BS-G_NBS	Right	0.320	0.573	5.471	<0.001	1.070	0.196	0.684	1.456
	G_BS-G_NBS	Left	2.122	0.147	5.922	<0.001	1.077	0.182	0.718	1.436
Palm length	G_BS-G_NBS	Right	1.268	0.262	8.201	<0.001	0.904	0.110	0.686	1.122
	G_BS-G_NBS	Left	2.751	0.099	7.676	<0.001	0.854	0.111	0.635	1.074
Hand breadth	G_BS-G_NBS	Right	3.275	0.072	5.590	<0.001	0.614	0.110	0.397	0.830
	G_BS-G_NBS	Left	4.564	0.034	5.638	<0.001	0.617	0.109	0.401	0.833
Hand span	G_BS-G_NBS	Right	11.748	0.001	9.911	<0.001	2.329	0.235	1.865	2.794
	G_BS-G_NBS	Left	6.545	0.011	9.748	<0.001	2.294	0.235	1.829	2.759
Pinky finger	G_BS-G_NBS	Right	7.075	0.009	10.675	<0.001	0.674	0.063	0.550	0.799
	G_BS-G_NBS	Left	7.664	0.006	9.508	<0.001	0.631	0.066	0.500	0.762
Ring finger	G_BS-G_NBS	Right	1.700	0.194	5.531	<0.001	0.412	0.074	0.265	0.559
	G_BS-G_NBS	Left	1.869	0.174	5.124	<0.001	0.379	0.074	0.233	0.526
Middle finger	G_BS-G_NBS	Right	0.693	0.406	9.208	<0.001	0.708	0.077	0.556	0.860
	G_BS-G_NBS	Left	0.748	0.388	9.154	<0.001	0.673	0.074	0.528	0.818
Index finger	G_BS-G_NBS	Right	4.896	0.028	8.575	<0.001	0.584	0.068	0.449	0.718
	G_BS-G_NBS	Left	6.727	0.010	8.598	<0.001	0.560	0.065	0.431	0.688
Thumb	G_BS-G_NBS	Right	8.770	0.004	8.641	<0.001	0.526	0.061	0.406	0.646
	G_BS-G_NBS	Left	16.926	<0.001	8.548	<0.001	0.518	0.061	0.398	0.637

G_TS—group of ball sports; G_NBS—group of non-ball sports; ΔX—mean difference; SED—Std. Error Difference; F—Fisher test value; t—value of Student T-test; and *p*—Sig. level (2-tailed).

Table 4. Limb Symmetry Index (SI) and limb directional asymmetry (DA) of the upper limbs of the group practicing non-ball sports (G_NBS) and the group practicing ball sports (G_BS).

Parameters	G_NBS			G_BS		
	SI	DA	Direction of Asymmetry	SI	DA	Direction of Asymmetry
Upper limb length	−0.090	−0.045	Left	−0.317	−0.158	Left
Hand length	0.325	0.162	Right	0.276	0.138	Right
Palm length	−0.218	−0.109	Left	0.219	0.110	Right
Hand breadth	0.064	0.032	Right	0.012	0.006	Right
Hand span	−0.181	−0.091	Left	−0.005	−0.002	Left
Pinky finger	−0.054	−0.027	Left	0.641	0.320	Right
Ring finger	−0.183	−0.091	Left	0.253	0.126	Right
Middle finger	−0.109	−0.054	Left	0.336	0.168	Right
Index finger	−0.030	−0.015	Left	0.301	0.150	Right
Thumb	0.388	0.194	Right	0.489	0.244	Right

Table 1 shows the results of the anthropometric measurements of the right and left upper limbs of athletes who do not practice ball sports (G_NBS). The variance values indicate a relatively small spread for the sizes of all the fingers and for the palm lengths and hand breadths; for the upper limb lengths, hand lengths and hand spans, the spread is very high. The values of the coefficient of variation were <10%, which indicates a very good homogeneity for the group of players who practice sports without a ball, for all the analyzed anthropometric parameters. For the group of athletes who practice ball sports (handball and basketball), the results of the anthropometric measurements of the right and left upper limbs indicate a relatively small spread for the sizes of all the fingers and for the palm lengths and hand breadths; for the upper limb lengths, hand lengths and hand spans, the spread is very high. The values of the coefficient of variation for all the anthropometric parameters of the upper limbs were <10%, which reflects a very good homogeneity for the group of players who practice ball sports (Table 1).

Table 2 shows the results of the statistical analysis of the anthropometric measurements between the upper right and left segments for athletes who practice sports without a ball (G_NBS). Analyzing the results, it can be seen that the differences recorded between the right and left side are not statistically significant for the reference threshold $p < 0.05$ for the following parameters: upper limb length, hand length, hand breadth, hand span, pinky finger, middle finger and index finger. Statistically significant differences were identified for the palm length, ring finger and thumb. The dimensions of the upper right segment are larger than the left side only for the following three anthropometric parameters: the hand length by 0.060 cm, hand breadth by 0.005 cm and thumb by 0.021 cm; the other anthropometric dimensions are larger for the left side compared to the right. The biggest differences identifying the asymmetries between the right and the left side were recorded in the upper limb length with −0.067 cm and the hand length with 0.060 cm; symmetries were registered for the hand breadth with 0.005 cm and the pinky finger and index finger with 0.002 cm. The differences in the arithmetic averages between the two segmental parts for all the measured anthropometric parameters fell between the two limits of the 95% CI.

Analyzing the results between the upper right and left segments for the athletes who practice ball sports (G_BS), it can be noticed that the differences recorded are statistically significant ($p < 0.05$) for all the anthropometric parameters with two exceptions: the hand breadth ($p = 0.765$) and hand span ($p = 0.946$). The differences in the arithmetic averages between the two right and left sides, for all the anthropometric parameters measured, fell between the two limits of the 95%CI (Table 4). For the G_BS, the dimensions of the upper right segment (dominant, with which the ball is predominantly handled) are larger than the left (non-dominant) side for the following anthropometric parameters: the hand length by 0.053 cm; palm length by 0.025 cm; hand breadth by 0.001 cm; pinky finger by 0.041 cm; ring finger by 0.019 cm; middle finger by 0.027 cm; index finger by 0.022 cm; and thumb by 0.029 cm. Larger anthropometric dimensions for the left side compared to the right side were recorded in the following parameters: the upper limb length by 0.253 cm and the hand span with 0.001 cm. The biggest asymmetries between the right and the left side were recorded: the upper limb length with −0.253 cm, hand length with 0.053 cm and pinky finger with 0.041 cm; the best symmetries were registered for the hand breadth and hand span with 0.01 cm (Table 2).

Table 3 shows the statistical processing of the results between the two study groups. By analyzing the T-test values recorded in this study, it is obvious that the differences between the two groups, for each anthropometric parameter, for each right and left side, are statistically significant. The differences in the arithmetic averages recorded for each anthropometric parameter on each right and left side fell between the lower and upper limits of the 95% CI. Comparing the results between the two groups, for the group from the ball sports (G_BS), we find that the following dimensions of the anthropometric parameters of the right side are greater than those of the left side: palm length by 0.904 cm; pinky finger by 0.674 cm; ring finger by 0.412 cm; middle finger by 0.708 cm; index finger by 0.584 cm; and thumb by 0.526 cm. The dimensions of the left side of the ball sports group (G_BS_) are larger than those of the non-ball sports group (G_NBS) for the following anthropometric parameters on the right side: the upper limb length by 6.246 cm; hand length by 1.077 cm; hand breadth with 0.617 cm; and hand span 2.294 cm.

The most relevant symmetries, between the two groups, were recorded in the following anthropometric parameters on the right side (recording the smallest average differences): ring finger 0.412 cm and thumb 0.526 cm; for the left side, they were the ring finger 0.379 cm and thumb 0.518 cm. The biggest asymmetries between the two groups were recorded, for both right and left sides, in the following parameters: upper limb length > 6 cm; hand span > 2 cm; and hand length > 1 cm. For all the analyzed parameters, the athletes from the ball sports group (G_BS) recorded higher average values than those from the non-ball sports group (G_NBS) for both parts of the upper segments, which reflects the fact that handling the ball over a long period of time, starting from the beginning of practicing sports and up to the age of seniority, determines changes in the dimensions of the upper segments, especially of the hand.

Analyzing the Limb Symmetry Index (SI) results from Table 4, for the G_NBS, we found that the largest asymmetries were in the following parameters: hand length with 0.325, thumb with 0.388 and palm length with −0.218; for the G_BS, the biggest asymmetries were identified in the anthropometric parameters: pinky finger with 0.641, thumb with 0.489 and middle finger with 0.336. Analyzing the limb directional asymmetry (DA) values, we found that for the G_NBS, the asymmetries indicate that the right side of the upper limb (dominant) in the anthropometric parameters, the hand length, hand breadth and thumb, and most of the parameters are directed toward the left (non-dominant): upper limb length, palm length, hand span, pinky finger, ring finger, middle finger and index finger. For the G_BS, we state that only two parameters are directed toward the left side (non-dominant): upper limb length and hand span; all the other parameters are oriented toward the right side of the upper limb, which also represents the dominant part of the subjects in the G_BS.

4. Discussions

The present study focused on the identification of asymmetries between the dimensions of the upper limbs, in relation to manual laterality, of the athletes who practice team sports with a ball and those who practice other sports without a ball. The results of this study reveal that there are significant differences between the ball sports group (G_BS) compared to the non-ball sports group (G_NBS) for all the measured anthropometric dimensions between the right and the left upper segment. Analyzing the results between the right and left upper segment for the athletes from the G_BS, it can be seen that the differences recorded are statistically significant ($p < 0.05$) for all the anthropometric parameters with two exceptions, the hand breadth and hand span, where the differences were not statistically insignificant. Analyzing the G_NBS results, we find that the differences recorded between the right and left side are not statistically significant for the following parameters: upper limb length, hand length, hand breadth, hand span, pinky finger, middle finger and index finger. Statistically significant differences for the G_NBS were identified for the palm length, ring finger and thumb. For both groups, the dimensions of the anthropometric parameters on the dominant (right) side were greater than on the non-dominant (left) side.

The results of our study facilitate the understanding of how the practice of ball sports influences the anthropometric parameters of the upper limb, especially at the level of the hand in relation to the size of the ball, the level of technical mastery and the technical requirements and ball handling requirements specific to the respective sport [49,50]. The results of our study are in line with previous studies that identified asymmetries between the anthropometric parameters of the upper limbs depending on the different characteristics of the groups of subjects and in relation to different aptitudes and motor skills [51,52]. Our study completes the level of knowledge regarding how practicing ball sports influences the development of anthropometric parameters regarding symmetries and asymmetries in the upper limbs [53,54].

A series of studies have highlighted the link between the anthropometric dimensions and handgrip strength of the players, as well as with the execution level of technical skills, concluding that there are positive correlations between these three parameters [55,56]. The studies highlighted that there is an interdependence between the motor (strength and endurance) and functional capacity and the anthropometric ratios of the fingers and the hand, differentiated between male and female groups [21,57–59].

A study carried out on 343 men and 290 women, adults, focused on the measurement of four anthropometric dimensions of the right and left hand and identified significant differences for all parameters, this fact being in correlation with the preferred hand [60]. The results of the mentioned study substantiate the results of our study, in which significant statistical differences were identified between different anthropometric parameters between the right hand (dominant, in the case of the present study) and the left hand. Numerous studies have highlighted anthropometric differences between the right-hand and the left-hand parameters, depending on gender [61–63]; ethnicity [64,65]; occupation [66,67]; and laterality [68–70]. A study conducted on 161 university student subjects identified significant differences between the male and female samples, with the male group recording an average hand width of 7.57 cm [71]. The results recorded in the previously mentioned study [71] were very similar to our male sample of those who do not practice ball sports (hand breadth: right, 7.759 cm; and left, 7.754 cm). The identification of the factors that influence the anthropometric development of the body and the practice of different physical activities on the body symmetry must be approached in an interdisciplinary manner to facilitate their complex understanding from the perspective of health [72–74]; physical exercise [1,75]; education, etc. [76,77].

The results of our study regarding limb directional asymmetry (DA) highlight that the asymmetry is directed predominantly on the dominant right side for the G_BS group in eight anthropometric parameters, and only in two parameters (upper limb length and hand span) is the asymmetry directed toward the non-dominant left side. For the G_NBS group, we identified that only 3 parameters out of the 10 highlight an asymmetry directed toward the dominant right side, and 7 anthropometric parameters show a direction toward the non-dominant left side. The Limb Symmetry Index (SI) values of the G_BS highlight large asymmetries (SI > 0.15) in five anthropometric parameters: hand length, palm length, hand span, ring finger and thumb; in the case of the G_NBS, large asymmetries were identified in eight anthropometric parameters: upper limb length, hand length, palm length, pinky finger, ring finger, middle finger, index finger and thumb. A series of studies carried out on athletes have identified asymmetry between the dominant and the non-dominant segment, which confirms the results of our study [46,78]. A study conducted on 36 handball players (average age 26.1 years) observed that the muscle mass and grip strength of the right upper limb is greater than that of the left; handball influences the asymmetric growth of body muscle hypertrophy [41]. The results of our study are confirmed by other studies that identified that the most frequent inter-limb discrepancies between the dominant and non-dominant side are determined by the frequent unilateral use of the dominant segment in performing technical skills depending on the specifics of the sport [41,79,80]. In another study conducted on 34 young male handball players in which inter-limb asymmetry was evaluated, they highlighted the need to adapt training in order to reduce inter-limb asymmetries in relation to long training periods [81]. A series of studies highlighted the relationship between the asymmetric development of the muscle mass of the upper limbs and the dimensions of the bones in subjects who practice sports that involve predominantly unilateral technical executions [82–84]. Studies have shown that asymmetries between the upper and lower segments increase the risk of injury with an impact on health and sports performance [85,86].

The limits of this study include measuring only the longitudinal and transversal anthropometric parameters, without measuring the circular parameters (circumference); not including female subjects in this study; limiting the age of the subjects to 20–24 years; failure to calculate the proportionality indices between different anthropometric parameters of the upper limbs, respectively, in relation to height; not using a gold standard (Dxa) measure to evaluate the anthropometric parameters; the inclusion in this study of only athletes practicing handball and basketball; and the G_BS results not correlating with the dimensions of the ball because they change depending on the level of the sports category (depending on age and gender).

Practical Implications

The practical implications of the results of this study can be directed at the modeling of sports training and at the adaptation and implementation of exercises to symmetrize the executions in order to ensure symmetry and harmonious physical development. Identifying the asymmetries of the upper limbs in relation to the sport practiced can contribute to adapting the training in order to correct these asymmetries and prevent some musculoskeletal disorders. During sports training, coaches and athletes can perform corrective and restorative exercises with a compensatory role to optimize physical potential. The asymmetries of the upper limbs as a result of practicing some sports that involve handling the ball or other objects and whose technique is predominantly unilateral also determine inequalities in terms of the involvement of physical abilities (usually, the dominant hand has superior strength, coordination, etc., parameters than the non-dominant hand) and the efficiency of technical skills. Studies have shown that the symmetrization of physical development has positive effects on harmonious physical development, body aesthetics and motor potential [75,87–89]. The relevant results from the present study can determine the adaptation of sports training by including corrective, compensatory and recovery exercises in order to reduce body asymmetries.

5. Conclusions

For the G_BS, asymmetries between the right and left sides were recorded for the upper limb length, hand length and pinky finger; the greatest symmetries were recorded for the hand breadth and hand span. For the G_NBS, the biggest differences regarding the asymmetries between the right and the left side were recorded for the upper limb length and hand length; the best symmetries were registered for the hand breadth, pinky finger and index finger. The most relevant symmetries, between the two groups, were recorded for the following anthropometric parameters on the right side: the ring finger and thumb; for the left side, this was the following: the ring finger and thumb. The biggest asymmetries between the two groups were recorded, for both right and left sides, for the following parameters: the upper limb length, hand span and hand length. For all the analyzed parameters, the athletes from the ball sports group (G_BS) recorded higher average values than those from the non-ball sports group (G_NBS) for both parts of the upper segments. The results of this study reflect the fact that handling the ball over a long period of time, starting from the beginning of practicing the sport until the age of seniority, causes changes in the anthropometric dimensions of the upper segments, causing asymmetries between the dominant (right) and the non-dominant (left) side. Analyzing the Limb Symmetry Index (SI) for the G_NBS, we find that the positive symmetry was in the following parameters: the hand length, hand breadth and thumb; for the G_BS, it was the following: the hand length, palm length, hand breadth, pinky finger, ring finger, middle finger, index finger and thumb. The closest upper inter-limb symmetry was identified for the hand span and hand breadth for the G_BS and for the index finger and hand breadth for the G_NBS. The limb directional asymmetry (DA) highlights that the asymmetry is directed predominantly on the dominant right side for the G_BS group in eight anthropometric parameters, and only in two parameters (upper limb length and hand span) is the asymmetry directed toward the non-dominant left side. For the G_NBS group, we identified that only 3 parameters out of the 10 highlight an asymmetry directed toward the dominant right side, and 7 anthropometric parameters show a direction toward the non-dominant left side.

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