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Luisa Pizzigalli[1]*, Margherita Micheletti Cremasco[2], Antonio La Torre[3], Alberto Rainoldi[1], Roberto Benis[3]

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TITLE: Hand grip strength and anthropometric characteristics in Italian female national basketball teams

Authors: Luisa Pizzigalli[1]*, Margherita Micheletti Cremasco[2], Antonio La Torre[3], Alberto Rainoldi[1], Roberto Benis[3]

Institutional Affiliation:

[1]Motor Science Research Center, School of Exercise & Sport Sciences, SUISM, Department of Medical Sciences, University of Torino, Torino, Italy

[2]Department of Life Sciences and Systems Biology, University of Torino, Torino, Italy

[3] Department of Biomedical Sciences for Health , University of Milano, Milano, Italy

Corresponding Author:

Luisa Pizzigalli

Motor Science Research Center, School of Exercise & Sport Sciences, SUISM, Department of Medical Sciences, University of Turin.

P.za Bernini 12 -10143-Torino, Italy.

luisa.pizzigalli@unito.it

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ABSTRACT

The aim of this study was to investigate the influence of hand and body dimensions on hand grip strength and to define a reference scale for talent identification in basketball players.

Body and hand anthropometric data and the maximal handgrip strength of 109 female Italian basketball National players (Under14-Seniores) were measured.

Handgrip strength and arm length trend increased, raising the statistical significant differences only for players from the age of 19 (U20, Seniores) with respect to sub-elite groups (U14, U15) ($p<0.05$). Handgrip strength showed low positive correlations with height and BMI but a positive relationships with arm length ($r=0.5$; $p<0.001$). Findings underline training and years of practice have effects on increasing handgrip strength.

Data show that to select female basketball players by arm length means selecting by handgrip strength. Thus it is possible to suggest that in addition to height, arm length could also be considered a useful parameter in young female talent identification.

Keywords: Anthropometric measures - Handgrip strength – Basketball Players – Talent identification

INTRODUCTION

Basketball is an aerobic-anaerobic based sport [1] which requires muscular strength conditioning both in lower and in upper limbs [2]. In basketball a number of movements rely on the continuous use of wrist and digit flexors in catching, holding, shooting and passing, so hand strength is fundamental in this game [3, 4]. Upper extremity muscle and grip strength are the primary physical factors affecting passing accuracy. Moreover, all shots and passes work more efficiently when the hand surface parameters are larger and when the fingers are longer and stronger (which probably yields better handgrip strength) [3, 5].

In fact, in basketball, as in the other popular sports such as volleyball, softball and handball, where the relation between hand and ball is fundamental, handgrip strength and anthropometric dimensions were investigated [3, 5, 6, 7]. Basketball is recognized as being a complex technical game. Performance differences between players of varying ability levels have also been identified in the body anthropometric characteristics [8] but, as underlined by the above mentioned studies, hand dimensions and a sufficient degree of grip strength are also necessary to be successful, starting when players are young. Such a positive correlation among hand strength and body anthropometric parameters (height, weight and body mass index-BMI) has been evaluated in children and adolescents in many studies [9, 10, 11, 12, 13, 14].

In sport, talent identification programmes detect potential young athletes using different performance variables, including several anthropometric measurements, especially in ball games where morphological characteristics of the players are more important as these generate evident

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effects on their skill and teams strategy, e.g. height in basketball [15]. A lack of anthropometric data collected in basketball elite players actually limits this talent identification approach.

In the field of sport games, some studies considered body and hand anthropometric parameters in relation to performance [16,17] both for talent identification and for playing position assignments [18], but the relationship between handgrip strength and both hand and body anthropometry is not always considered. To the best of our knowledge, the information related to the correlations of hand dimensions, anthropometric variables and grip strength in female basketball players still remains largely unreported. A limited number of studies assessed hand strength and anthropometric parameters in young female basketball players [19, 20] but under-19 and senior elite levels were not included.

The aims of this study of women's Italian National basketball teams were three-fold.

(a) To evaluate the trend of right and left hand grip strength in a cross-sectional study extended from under 14 to senior elite athletes allowing the definition of a reference scale; (b) to investigate whether there is an influence of the body anthropometric and (c) dominant hand dimensions on hand grip strength. These latter findings could help in identifying which body or hand parameter could be used to aid new talent detection.

METHODS

Experimental approach to the problem

The present cross-sectional study was conducted to compare the relationships between hand (e.g. hand length, transversal and span), body anthropometric (e.g. height, weight, body mass index [BMI] and arm length) parameters and handgrip strength in Italian National female basketball players.

Subjects

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In total 106 basketball-playing Italian girls, aged 19±4 (mean±SD) years participated in the study. The National elite athletes were divided into 7 competition level groups that correspond to the chronological age groups - under-14 competition level group with 18 participants aged from 13 to 14, under-15 with 16 participants aged 15, under-16 with 16 participants aged 16, under-17 with 13 participants aged 17, under-18 all 16 participants aged 18, under-20 with 11 participants aged from 19 to 20 years old, and seniores with 19 participants aged from 21 to 32 years old (26.2±3.9). Biological age of the athletes was not measured because they were selected only by chronological age for the competitions. Practice information (frequency and hours of training, matches and years of practice) of Italian women's National basketball teams are presented in Table I. During training sessions no specific exercises for increasing handgrip strength or specific hand training methods were used. All players belonged to teams participating in the Italian National Championship 2014/2015. All subjects were healthy, and none of them was taking any medications at the time of the study. They did not experience any pain or disability in their upper extremities. All athletes and their coaches were informed of the purposes and content of the experiment; written informed consents were obtained from each player, and also the consent of a parent for subjects younger than 18 years was required. The research was undertaken in compliance with the Helsinki Declaration and was approved by the Medical Ethics Committee of the Department of Biomedical Sciences for Health, University of Milan (Italy).

TABLE I

Measurements of body anthropometric parameters

The International Standard ISO 7250-1 [21] was adopted for all anthropometric measurements.

The standard measuring instruments used were the anthropometer, the sliding callipers and the weighing scale. During measurement subjects wear minimal clothing and no shoes. Descriptive

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statistics of anthropometric characteristics are shown in Table II. Body mass was obtained to the nearest 0.1 kg using a weighting digital scale (Tanita TBF 350-Tokyo, Japan)

Body height (stature) was measured using an anthropometer (Sieber Hegner-GPM-Zurich, Switzerland) to the nearest 0.01 m

Body mass index (kg/m^2) (BMI) was calculated as the ratio between weight and the square of height representing the easiest method to calculate any state of underweight, overweight or obesity.

Arm length (cm) was measured from the acromion (lateral edge of the acromion process, e.g. bony tip of shoulder) to the dactylion (the extreme tip or end of the middle finger when the hand is fully extended) as used in previous studies [22, 23].

TABLE II

Measurements of hand anthropometric parameters

Hand anthropometric parameters were measured respecting hand preference [24]. Hand dimensions were measured by to the nearest 0.1 cm using a sliding calliper (GPM -Switzerland). From the total of 106 participants involved in the study, the right hand was dominant for 97.3% (one athlete dominant left in U14, U15, U18 respectively). Hand length and breadth measurements were taken following ISO 7250-1 [21] and the subject held the forearm horizontal with the hand stretched out flat and palm up. Maximum hand spread (five fingers' span) was measured following [22] (Tab.III).

TABLE III

Measurements of handgrip strength

The maximal handgrip strength of both hands was measured with the portable JAMAR Hydraulic Hand dynamometer (Sammons Preston Rolyan Nottinghamshire, UK) as recommended for use in sport [25, 26]. It was regulated for each subject: fitting the hand and allowing flexion at the

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metacarpophalangeal joints. The scale of the dynamometer indicated handgrip strength in kilograms (kg). Both non dominant and dominant hands were measured in accordance with the specific aims: (a), (c) of the study.

The testing protocol consisted of three maximal voluntary isometric contractions maintained for 5 s, on both hands, with rest period of at least 60 s; the highest value was used for the determination of the maximal grip strength.

During the hand strength testing protocol the subject sat upright against the back of a chair with feet flat on the floor [27]; the arm position was standardized with the shoulder adducted and neutrally rotated, elbow flexed to 90° [28]. The forearm and wrist were in a neutral position resting on the support surface [11, 27, 28, 29, 30]; the hand was maintained in line with the forearm holding the instrument upright on its base on the short side.

Specific verbal instructions were given to subjects before the evaluations [29, 31] and the experiments were performed with verbal encouragement [32, 33].

Three tests were randomly carried out for the right hand and three for the left one, with one minute of rest among trials and the highest performance was selected [11, 25].

STATISTICAL ANALYSES

Standard statistical methods were used to calculate mean and standard deviation (mean±SD). The differences among groups were determined by the non-parametric Kruskal-Wallis test, e.g. right handgrip strength differences in sport level groups. The post hoc Dunn's tests were performed when necessary to isolate the differences. Differences within groups were investigated with the Wilcoxon test e.g. differences between right and left handgrip strength in sport level groups. Pearson's correlation coefficient was used to evaluate the correlation among variables, e.g. relationships among handgrip strength, hand and body anthropometric parameters in all groups.

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For all tests the significance level was set at a p level ≤0.05 and Bonferroni multiple comparisons were performed using GraphPad Prism version 6.00 for Windows (GraphPad Software, La Jolla California, USA) and SPSS 15.0 (SPSS Inc. Chicago, Illinois, USA).

RESULTS

(a) Handgrip strength trend in sport level groups

Supporting the classical findings of many investigations, handgrip strength trend increases in both hands with age and the sport level from the under-14 group up to the seniores group (Fig.1). However, we observed an exception for the under-17 and under-18 groups, who show lower handgrip strength values than under-16 in both hands. These differences do not raise the statistical significance at the U-Mann Whitney test, under-16 handgrip strength data versus under-17 handgrip strength data (ns), and under-16 handgrip strength data versus under-18 handgrip strength data (ns), in both right and left hands.

FIGURE 1

The Kruskal-Wallis test for both right (Fig.2) and left (Fig.3) handgrip strength show statistically significant differences among the highest (seniores and under-20) and the lowest (under 14 and under-15) sport level groups ($p<0.05$).

FIGURE 2

FIGURE 3

At the Wilcoxon test no differences (ns) between the right and left grip strengths were found for all sport level groups, except for the seniores group (Fig. 1), the only sport level group in which significance was reached ($p<0.01$) (Tab.4).

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TABLE IV

(b) Relation among handgrip strength and body anthropometric dimensions

No statistically significance differences were showed for height, weight, BMI among all basketball level groups.

With the Kruskal-Wallis test the arm length data showed differences among groups ($p<0.001$) (Fig.4).

There were significant but low positive relationships among handgrip strength values of both hands and body anthropometric dimensions as body height, BMI in all subjects ($r=0.3$-0.4) ($p<0.01$). The correlation with handgrip strength (both right and left side) showed a moderate positive relationship ($r=0.5$) ($p<0.01$) with weight and with arm length (Tab. 5). To the best of our knowledge, this is the first work that shows this aspect of the arm length parameter in female basketball players. As expected, arm length also showed the highest correlation value with height ($r=0.7$) ($p<0.01$) with respect to all anthropometric parameters.

FIGURE 4

TABLE V

(c) Relation among handgrip strength and hand anthropometric dimensions

No statistically significance differences were shown for hand dimensions (span, length, transversal) among all basketball level groups (Tab. 6). Moreover, hand length and hand transversal were not correlated (Tab. 5).

TABLE VI

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There were low but significant relationships among handgrip strength values of both hands and hand anthropometric dimensions such as hand span and hand transversal in all subjects (r=0.2-0.3) ($p<0.05$). No statistically significant correlations were found among both handgrip strength values and hand length (Tab. 5).

DISCUSSION

The aim of the study was to investigate hand grip strength in women's basketball National teams at different elite sport levels to evaluate its relation to hand and body anthropometric dimensions. The identified relationship, from under 14 to senior elite athletes, is proposed as a reference scale useful in talent detection and in coaching suggestions.

All the categories of National athletes recruited in the study reported no statistically significant differences between handgrip strength of the two hands, as reported in non-athletes and in basketball players during late childhood [25, 34]. Chahal and Kumar [35] instead, found that handgrip strength was higher in the non-dominant (left) hand in 10-16 years old male basketball players. In the present study statistically significant higher values were achieved in the dominant (right) hand only in the senior sport level group ($p<0.001$). Probably the conditioning (frequency, intensity, volume and mode of strength training) [36], but also years of practice (Tab. 1) could be the cause of this muscular asymmetry reached in the top level category. During play both hands are used in techniques and tactics such as left and right hand rebounding, lay ups, deflection, passing, fake and feints. The dominant hand is used mostly for shooting, passing and dribbling. Handgrip strength is a basilar component not only in these basketball basic moves but also in defensive and offensive manoeuvres and the repetition of these tasks is an athletic career effect. In fact, findings showed a handgrip strength trend increase

in both hands, as well as increasing with the sport level, raising the statistically significant differences ($p<0.05$) in under-20 and seniores in respect to the younger groups (Fig.2-3). This data underlines that conditioning (about 7 time in a week, 14 hours/week) and practice years (at least 10

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years) (Tab.1) are pivotal for increasing hand strength. Moreover, muscolo-skeletal improvement is completed in females around 19 years for muscle mass, while this already takes place at around 14 years for hand bones but only around 20 years for arm bones [37, 38]. In confirmation of these physiological aspects, no statistically significant differences were shown for hand dimensions among all elite level groups, neither for length and transversal anatomical measures nor for functional dimension such as hand span, but only for arm length dimensions ($p<0.001$). Comparing the mean hand transversal with non-athlete Italian adult females [39], the National basketball athletes exceed 50° percentile, while hand length measures exceed 95° percentile. In stature also all national sport level athletes exceed 95° percentile. These aspects confirm that anthropometric selection in female Italian basketball players is based on stature values [15], as for male players [16]. Findings underline that height is independent of hand length values (Tab.5). Although height is considered to be the most important physical characteristic in basketball players, it is not related to transversal and span hand dimensions ($r=0.3$ and 0.4 respectively). Concerning hand dimensions, in sports involving grasping an object such as basketball, players with bigger hands and longer fingers have greater accuracy in the shot [5]. In our study body anthropometric measurements (height, and BMI) showed low positive correlations with both handgrip strength values, whereas body weight and arm length were the best correlated variables ($r=0.5$; $p<0.001$). Body weight predicted handgrip strength more than BMI, particularly in athletes, thanks to their muscular mass composition [6, 37].

On the other hand, only physical training seems to generate handgrip strength differences among level groups (in under-20 and in senior groups in respect to sub-elite level groups) (Tab.1, Fig.2-3) ($p<0.05$).

Moreover, data showed a high correlation among height and arm length ($r=0.7$; $p<0.001$) and low among height and hand dimensions, so female basketball players selection by hand anthropometric dimensions does not mean selecting them by handgrip strength as for basketball males [3]. Thus, arm length selection involved hand strength selection in basketball females because this

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anthropometric measure was shown to be a good predictor of handgrip strength ($r=0.5$; $p<0.01$). In fact, seniores showed higher values than younger groups (under-14 and under-15) not only for handgrip strength but also for arm length ($p<0.05$). In conclusion, for the first time in literature we observed that arm length could be a simple, reliable and repeatable talent identification measure when handgrip strength evaluation is not possible. This approach is already adopted in handball [23] but appears to be innovative in basketball.

In the present study, for all participants, body anthropometric dimensions (as weight and arm length) showed a positive relationship ($r=0.5$) ($p<0.01$) with handgrip strength values, whereas Massy-Westropp and co-authors in 2011 [40] found a lower correlation in normative females. On the other hand, only physical training seems to generate statistically higher values of hand grip strength among different level groups (in under-20 and in senior groups with respect to sub-elite level groups).

Current talent identification in young basketball athletes is just about the highest stature percentile [41], as confirmed by the data presented here on national Italian athletes. However, such a criterion does not ensure the selection of either those with the largest/longest hands or the strongest, as would be the case if the longest arms are selected. Thus it is possible to suggest that in addition to height, arm length could also be considered as a useful parameter in young female talent identification and as a pivotal factor in increasing team handgrip strength.

Since handgrip strength is crucial for athletic performance improvement [3, 23], it is important to underline that higher conditioning effects on handgrip strength are achieved after the age of 19 years (Fig.1). These factors confirm that handgrip strength gains are due to improvement in a number of neurological factors, such as neural recruitment, synchronization of motor unit fibres, and better motor skills coordination and maturation [23, 42]. These results confirm that athletes with specific body anthropometric values like height, arm length and weight might have biomechanical advantages with respect to handgrip strength.

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Considering this information, coaches and athletic trainers should be conscious of the importance of the handgrip strength conditioning, while talent scouts should be aware of arm length role in female basketball players talent recruitment. In fact handgrip strength trend showed in this study could provide a reference scale in order to organize an effective strength conditioning, to avoid sports-specific injuries, and finally to improve players performance in different women basketball categories.

CONCLUSIONS

This study has shown for the first time anthropometric and hand strength parameters in Italian women's National basketball teams. Particularly, this study provides evidence about the influence of body metrics (height, weight, and arm length) on handgrip strength in the female basketball players. Data shown in the present study offers practical applicability and should be useful in future investigation of player selection, talent identification in basketball and in training programme development. Since there is a paucity of data in this area, future longitudinal studies that will track the stability and changes in the above-mentioned attributes are needed.

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Figure 1. Handgrip strength trend of the right and left hands, in elite basketball level groups.

Figure 2. Kruskal-Wallis test differences among sport level groups for the right handgrip strength ($p<0.05$). At the Dunn's post hoc test under 14 versus seniores ($p<0.0001$) and under 15 versus seniores ($p<0.05$).

Figure 3. Kruskal-Wallis test differences among sport level groups for the left handgrip strength ($p<0.05$). At the Dunn's post hoc test under 14 versus under 20 ($p<0.05$)and under 14 versus seniores ($p<0.01$).

Figure 4. Kruskal-Wallis test differences among sport level groups for the arm length ($p<0.001$). At the Dunn's post hoc test under 14 versus under 20 and seniores ($p<0.001$); under 15 versus under 20 and seniores ($p<0.05$).

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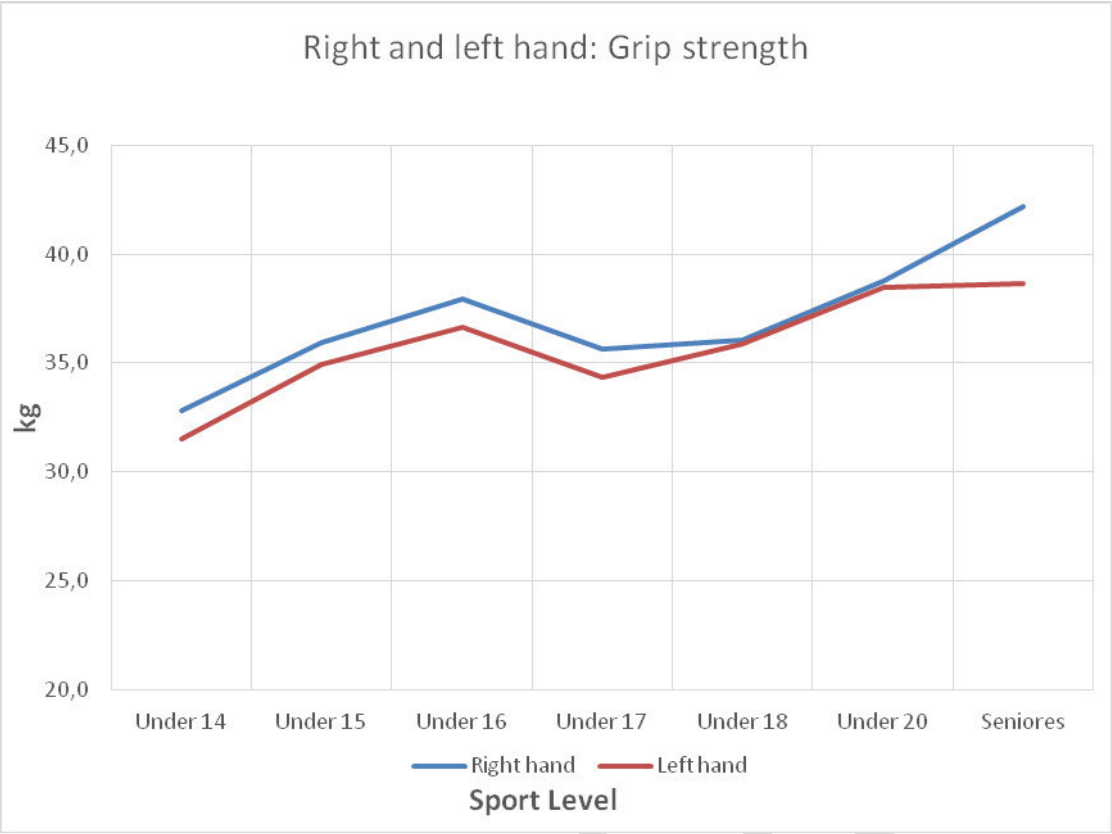

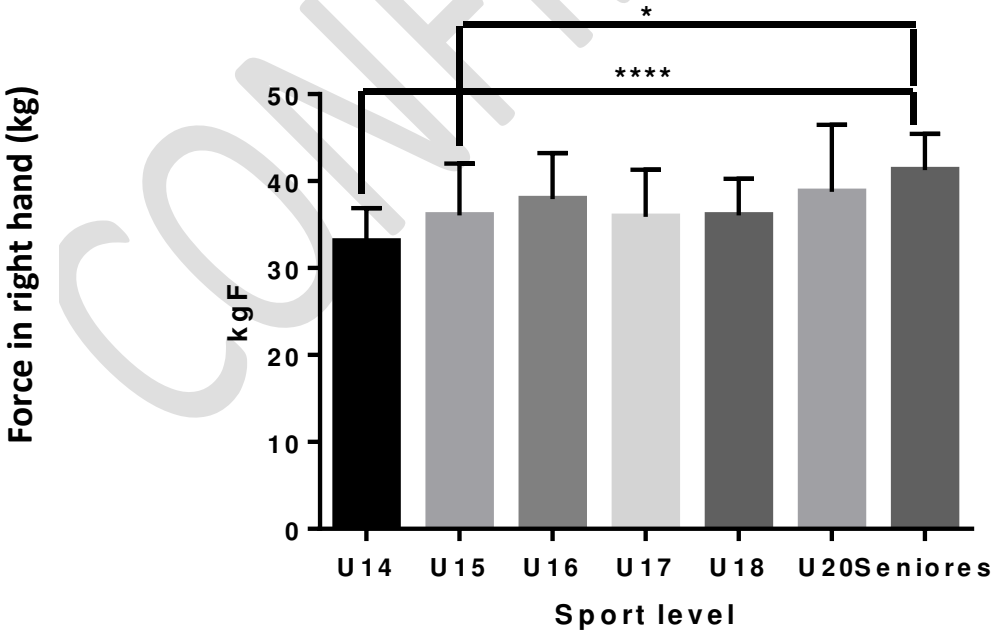

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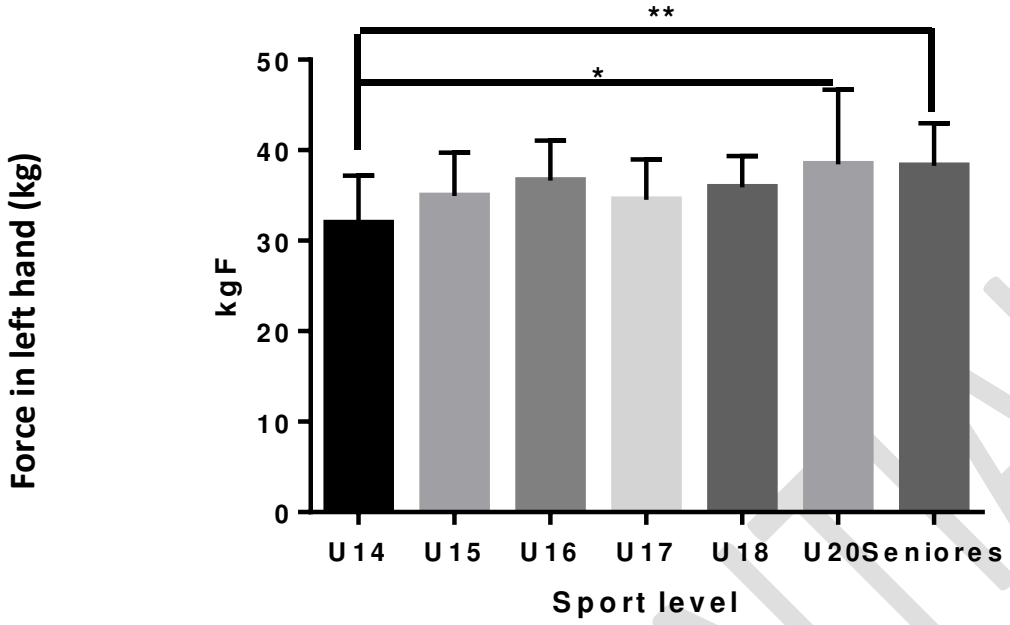

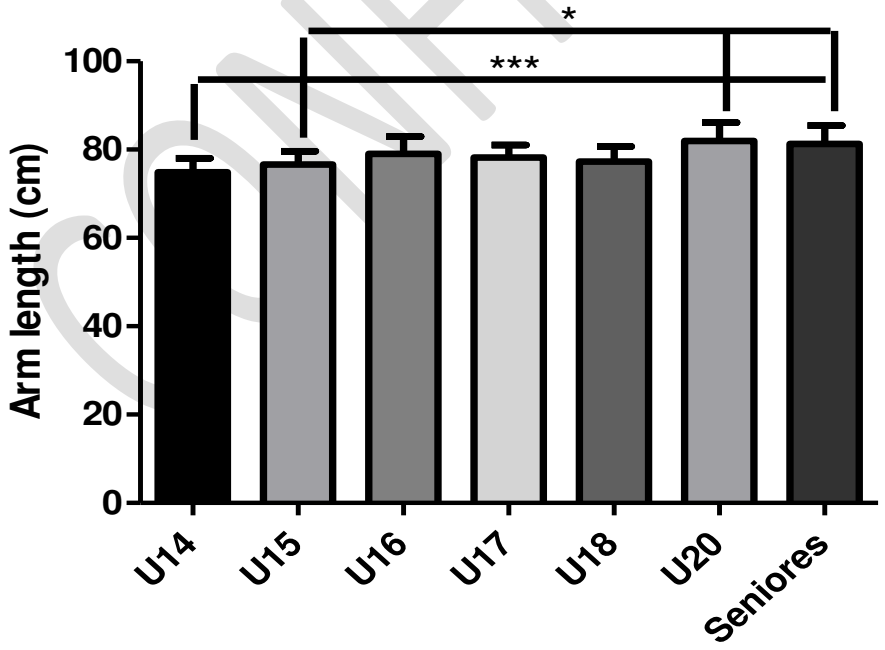

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SPORT LEVEL	PRACTICE FREQUENCY *(Time/week)*	PRACTICE HOURS/WEEK *(Training & matches)*	COMPETITIONS YEARS *(Practice years-left side & Italian National Championship years-right side)*	
Under 14	3	6	5	1
Under15	3	7	6	2
Under16	4	8	7	3
Under 17	4	8	8	4
Under 18	4	8	9	5
Under 20	7	14	12	6
Seniores	8	16	16±2	10±2

Table I. Practice information (frequency and hours of training, matches and years of competitions) of Italian women's National basketball teams.

	U14	**U15**	**U16**	**U17**	**U18**	**U20**	**Seniores**
Height (cm)	174.1±5.4	173.6±5.9	180.4±7.2	178.9±7.1	178.5±6.7	177.1±8.3	179.1±7.3
Weight (kg)	63.7±10.1	66.1±9.3	72.5±8.1	71.9±9.7	71.1±8.3	68.1±8.5	73.3±7.8
BMI (kg/m^2)	20.7±2.6	21.9±2.7	22.2±2.2	22.3±1.9	22.2±1.6	21.6±1.3	22.8±1.6
Arm length (cm)	74.4±3.1	76.2±3.0	79.0±3.7	77.0±3.0	77.8±3.9	81.9±4.0	80.7±3.9

Table II. Anthropometric measurements of Italian women's National basketball teams (m±SD) at different sport levels.

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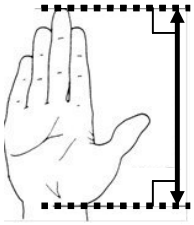
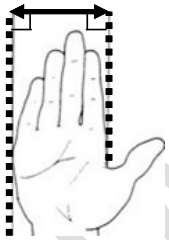
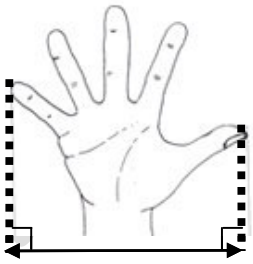
Hand Length (ISO 7250-1 4.3.1) Perpendicular distance from a line drawn between the styloid processes to the tip of the middle finger. The point of measurement at the styloid process corresponds approximately to the middle skin furrow of the wrist.	
Hand transversal Hand breath at metacarpals (ISO 7250-1 4.3.3) Projected distance between radial and ulnar metacarpals at the level of the metacarpal heads from the second to the fifth metacarpal the styloid processes to the tip of the middle finger.	
Hand spam Maximum hand spread (five fingers' span) **(Peebles & Norris, 1998-141)** Measured from the outer border of the tip of the little finger to the outer border tip of the thumb. The fingers and thumb are stretched as widely apart as the person finds comfortable.	

Table III. Hand anthropometric measurements: descriptions and standards, modified from ISO 7250 [21]; Peebles and Norris [22].

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Sport level groups	Right hand strength (m±SD)	Left hand strength (m±SD)	Wilcoxon p value
Under 14	32.8±4.2	31.5±6.0	.367 (ns)
Under 15	35.9±6.7	34.9±5.3	.093 (ns)
Under 16	37.9±5.3	36.7±4.4	.291 (ns)
Under 17	35.7±4.9	34.3±4.4	.200 (ns)
Under 18	36.1±4.0	35.9±3.8	.906 (ns)
Under 20	38.8±7.7	38.5±8.2	.388 (ns)
Seniores	42.2±4.6	38.7±5.6	**.001** **

*Table IV. Differences between right and left handgrip strength values in elite basketball level groups at the Wilcoxon test (p=0.002**).*

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	Height	Weight	BMI	Arm length	Hand spam	Hand length	Hand transversal	Right handgrip	Left handgrip
Height	1	**.693****	.052	**.730****	**.387****	-.108	**.291****	**.385****	**.404****
Weight	**.693****	1	**.806****	**.609****	**.336****	-.071	**.363****	**.483****	**.471****
BMI	.052	**.806****	1	**.203***	.070	-.002	.125	**.300****	**.304****
Arm length	**.730****	**.609****	**.203***	1	**.409****	-.122	**.240***	**.472****	**.466****
Hand spam	**.387****	**.336****	.070	**.409****	1	.038	**.445****	**.245***	**.269****
Hand length	-.108	-.071	-.002	-.122	.038	1	-.086	-.118	-.136
Hand transversal	**.291****	**.363****	.125	**.240***	**.445****	-.086	1	**.287****	**.240***
Right handgrip	**.385****	**.483****	**.300****	**.472****	**.245***	-.118	**.287****	1	**.842****
Left handgrip	**.404****	**.471****	**.304****	**.466****	**.269****	-.136	**.240***	**.842****	1

*Table V. Relationships among handgrip strength, hand and body anthropometric parameters in all groups. Pearson's coefficient of correlation (r) * p<0.05; ** p<0.01.*

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Sport level groups	m±SD	Hand spam (cm)	Hand lenght (cm)	Hand transversal (cm)
under 14	**mean**	20.1	19.1	8.7
	SD	1.1	1.1	0.7
under 15	**mean**	19.5	19.4	9.1
	SD	1.6	0.7	0.6
under 16	**mean**	20.5	19.4	9.4
	SD	1.5	0.9	0.7
under 17	**mean**	20.1	19.0	8.6
	SD	0.9	1.0	0.5
under 18	**mean**	19.4	18.7	8.9
	SD	0.8	0.7	0.5
under 20	**mean**	20.1	18.4	8.3
	SD	1.1	1.0	0.5
seniores	**mean**	19.9	19.4	8.9
	SD	1.0	0.5	0.2

Table VI. Mean and standard deviation of right hand anthropometric dimensions, in all sport level groups.

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