Assessment of handgrip strength in young handball players aged 9-16

A – preparing concepts
B – formulating methods
C – conducting research
D – processing results
E – interpretation and conclusions
F – editing the final version

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Abstract

Introduction: Strength is a primary component of human motor skills and one of the most frequently trained motor abilities. Handball belongs to a group of sports in which handgrip strength plays a key role. The aim of the study was to assess handgrip strength of children and adolescents handball players. This research may prove useful due to the need to monitor the training process. It will enable coaches and therapists to compare the results of children and adolescents with regard to age, gender and body dimensions as well as plan strength training programmes for handball.

Material and methods: The study was carried out on a group of 99 handball players from the "Handball Club" in Radzymiński Centre of Culture and Sport. The study included both boys and girls aged 9 to 16 who regularly and actively participated in handball training. The work presents basic anthropometric characteristics of the study participants and the results of handgrip strength measurements of both hands with the use of a hydraulic dynamometer.

Results: Handgrip strength increases with age in both girls and boys. Handgrip strength is greater in boys than in girls, which is connected with greater body mass, body height, relative body weight and phalanx length.

Conclusions: The given values of handgrip strength will enable coaches and therapists to compare the results of children and adolescents with regard to age, gender and body dimensions in order to monitor strength and plan strength training program in handball.

Key words: **handgrip strength, children and adolescents, handball, dynamometric evaluation**

Introduction

Strength is a primary component of human motor skills and one of the most frequently trained motor abilities. Appropriate strength is a condition of good general health state. It enables the body to successfully perform everyday motor activities [1].

The process of developing strength lasts for many years and is closely related to personal development. The level of strength development depends mainly on age, the level of physical activity and gender. The application of proper strength exercises in children and adolescents is indispensable for health and is a factor developing motor skills, preventing injuries and creating a basis for future strength development [2].

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However, high-intensity static strength exercises should not be applied in children and adolescents due to the ongoing process of the bone system development. After puberty, l strength exercises as well as other methods such as exercises with submaximal and maximal loads and strength-speed exercises involving maximum-speed repetitions may be implemented in training [3]. Due to the fact that the process of maturation finishes earlier in girls, these methods may be applied earlier than in boys [4].

Physical fitness is an expression of motor abilities which can be understood as "all motor capabilities both in the quantitative and qualitative meaning" [5].

Motor abilities of children and youth are associated with all motor activities which are determined by the level of the development of speed, jumping ability, motor coordination, flexibility, endurance and strength [6,7]. The main role in the development of motor abilities is played by the nervous system, the structures and the processes in a human brain. The first movements of a child are steered by the lowest parts of diencephalon and mesencephalic nucleus where dorsal pallidum located in the diencephalon area plays a role of a coordinator [8]. Commencing school education is another stage in a child's development. The passage from kindergarten, where the majority of time is devoted to spontaneous physical activity, to the system of lessons and classrooms and a forced sedentary position as well as to the functioning in a particular group structure leads to a lot of stress. A child's brain is still dominated by excitation processes and despite these limitations, motor abilities develop rapidly. The child quickly improves hand movements and learns to use new tools. The movements become more precise. At the age of 9-10, children develop the ability to concentrate, which helps them to perform previously acquired movements in a more precise and economic manner (without unnecessary gestures) and lets them enter a higher level of quality. At the same time, motor and sports skills, e.g. running and throwing, are developed further. The child becomes interested in competition. At the age of 10-13 [8-10], a puberty period begins in which an intensive growth pace is observed. In this period, the child gains an ability to learn new, even very complicated and complex motor skills. It is an ideal moment to start sports activity [11,2].

Children and youth training is a specific and expansive process occurring in stages due to the fact that physiological capabilities of the body are not fully shaped. The training should be adapted to the pace of developmental changes in the course of ontogenesis, current level of sports proficiency and time needed to achieve particular sports results [6].

Handball is a team sport played by women and men all over the world. It is characterised by high intensity, emotions and a high number of rules. Conditions during matches vary and are of interval character, so they require the highest level of proficiency from the players. During a game, players perform a number of complex motor activities in the form of anaerobic effort which are mixed with aerobic efforts. The training process is aimed at developing speed which is indispensable for moving on the court, rapid changes in the direction of movement, running with the ball at a high speed as well as performing jumps and shots in the conditions of being limited by opponents [12]. It is necessary to maintain a constant level of handgrip strength in order to increase the control and effectiveness of energy use and to reduce the risk of injury to a minimum [13]. It is a sport which is aimed at all age categories as game technique is based on natural forms of movement such as running, jumping, gripping or throwing, which also form the basis for other sports.

The aim of the study was to assess handgrip strength of healthy children and adolescents training handball with the use of a hand dynamometer. The following research hypotheses were formed:

1. There is a correlation between the participant's handgrip strength and age.
2. There is a correlation between the participant's handgrip strength and training experience.
3. There is a correlation between the participant's handgrip strength and body mass.

The following research questions were formulated:

1. Is there a difference in handgrip strength between a dominant and non-dominant upper limb?
2. Is there a correlation between handgrip strength and gender?

Material and Methods

The research included 99 players (boys - 37%, girls - 63%) aged 8-15 who regularly and actively trained handball. Congenital or acquired hand disorders (particularly in right and left hand fingers) constituted an exclusion criterion. Training sessions were conducted in two age groups, i.e. 8-13 years

and 14-15 years. The sessions in the younger group were 90 minutes long and were held twice a week, while in the older group, 90-minute sessions were held three times a week. Male and female players differed in terms of body height, body mass and training experience. The research was carried out during training sessions in the Handball Club of the Radzymiński Centre of Culture and Sport. Prior to the research, all individuals who qualified for the study had the length of their proximal phalanges of the right and left hand measured with the use of an analogue caliper. The measurements were made with an accuracy of 0.01 mm. In order to prepare the body to the effort, all the participants performed warm-up exercises before the measurement of handgrip strength. All the players were informed about the study protocol and about the fact that they can resign at any point. The study assessed quantitative and qualitative features. The analysis of each of them is different and requires adequate statistical tools. To describe the structure of the examined variables, basic descriptive statistics were calculated in the form of the measurements of positioning and variability. The normality of distribution was verified with the use of the Shapiro-Wilk test. Due to the lack of normality of distribution of the analysed variables, non-parametric tools were applied in further analyses. In order to determine the strength of correlations between the variables, Spearman's rank correlation coefficients were calculated. To verify whether gender significantly differentiated the analysed variables, a non-parametric equivalent of Student's t-test, i.e. Mann-Whitney U test, was applied. The level of significance was set at 0.05 for all the analyses. Each analysis was performed with the use of Statistica v.12 software.

Tab. 1. Characteristics of the examined boys and girls

BOYS					
	AGE [days]	**BM [kg]**	**BH [m]**	**BMI [kg/m^2]**	**EXPERIENCE [years]**
x mean	5010	70.5	1.7	21.8	1.5
SD	439	13	0.1	23.8	2
min	4226	38	1.50	3.1	5
max	5642	103	1.88	15.8	0.5
GIRLS					
	AGE [days]	**BM [kg]**	**BH [m]**	**BMI [kg/m^2]**	**EXPERIENCE [years]**
x mean	4414	46	1.6	18	3
SD	782	13	0.1	4	2
min	3067	25	1.2	12.2	1
max	5787	82	1.8	32.8	6

x – mean, SD – standard deviation, min – minimum, max – maximum, BM – body weight, BH – body height, BMI – body mass index

Handgrip strength measurement

In this study, the measurements of handgrip strength were made with the use of a hydraulic hand dynamometer. The measurements were performed in isometric conditions. After each trial, a maximal value of handgrip strength in kilograms (KG) was checked on the dynamometer and then it was recalculated into newtons (N). Afterwards, the dynamometer was zeroed. The applied dynamometer had a CE certificate and met the requirements of MDD93/42EEC directive regarding medical devices. The measurement was performed in the following manner: the participant is standing with one leg forward, the dynamometer is held closely adjoining the palm and fingers, an upper limb is flexed at 45˚ in the elbow joint, the other upper limb is held freely along the trunk. The participant squeezes the dynamometer with maximum effort which is maintained for 2-3 seconds. The researcher checks the score and dictates it to the person who is responsible for recording the results in the form. The handle, which has a 5-grade regulation from 3.4 to 8.5 cm (every 1.2 cm) was set at 3.4 cm for all the study participants. Both upper limbs were examined in the study. Two measurements were performed for each limb and a better result was taken into account. When the result was ambiguous, the third measurement was made. There were 1-minute intervals between the subsequent measurements.

In the course of the study, anthropometric measurements were also made, i.e. body mass, body height and the length of the proximal phalanx of the middle finger in both upper limbs were measured.

Results

Tab. 2. Correlation between handgrip strength and anthropometric parameters in children and adolescents training handball. The correlation coefficients are significant at p <.05000

Analysed variables	boys		girls	
	Spearman's R	p	Spearman's R	p
MMSH [N] & MLPH [mm]	0.65	0.00001	0.54	0.000
MMSH [N] & Age	0.76	0.00000	0.75	0.000
MMSH [N] & Age [years]	0.76	0.00000	0.74	0.000
MMSH [N] & Body mass [kg]	0.74	0.00000	0.83	0.000
MMSH [N] & Body height [m]	0.79	0.00000	0.79	0.000
MMSH [N] & BMI [kg/m2]	0.35	0.03487	0.73	0.000
MMSH [N] & Experience [years]	0.30	0.07564	0.74	0.000

MMSH – mean maximum strength of the right and left hand
MLPH – mean length of the phalanges of the right and left hand
BMI – body mass index

The analysis did not reveal significant correlations only between MMSH and training experience among boys. In the case of the remaining pairs of variables, all the correlations were strong and positive, i.e. together with an increase in the level of independent variables, MMSH also grew.

Tab. 3. Correlation between handgrip strength and anthropometric parameters of children and adolescents training handball. The correlation coefficients are significant at p <.05000

Analysed variables	boys		girls	
	Spearman's R	**p**	**Spearman's R**	**p**
MLPH [mm] & Age	**0.38**	**0.02**	0.326	0.010
MLPH [mm] & Age [years]	0.39	0.02	0.337	0.007
MLPH [mm] & Body mass [kg]	0.64	0.000	0.630	0.000
MLPH [mm] & Body height [m]	0.68	0.000	0.597	0.000
MLPH [mm] & BMI [kg/m2]	0.29	0.09	0.507	0.000
MLPH [mm] & Experience [years]	-0.00	0.99	0.312	0.014

MLPH – mean length of the phalanges of the right and left hand
BMI – body mass index

The analysis did not reveal significant correlations only between MLPH and training experience and BMI among boys (p>0.05). In the case of the remaining variables, all the correlations were strong and positive, i.e. the higher the variables, the higher the result.

Further analyses verified the significance of differences with regard to gender in particular age groups.

Table 4. Differences in anthropometric parameters, experience [years], BMI [kg/m2], body height [m], body mass [kg], handgrip strength [N] and the length of the proximal phalanx of the middle finger [mm] in children and adolescents training handball

Analysed variables	Sum of ranks boys (12 years)	Sum of ranks girls (12 years)	U	Z	p
MMSH [N]	91.00	99.00	21.00	1.73	0.083
MLPH [mm]	83.00	107.00	29.00	1.06	0.291
Body mass [kg]	93.50	96.50	18.50	1.94	0.052
Body height [m]	94.00	96.00	18.00	1.99	0.047
BMI [kg/m2]	88.50	101.50	23.50	1.52	0.128
Experience [years]	63.50	126.50	35.50	-0.51	0.612
Analysed variables	Sum of ranks boys (13 years)	Sum of ranks girls (13 years)	U	Z	P
MMSH [N]	119.00	71.00	5.00	3.18	0.001
MLPH [mm]	94.00	96.00	30.00	1.11	0.265

Body mass [kg]	112.50	77.50	11.50	2.64	0.008
Body height [m]	95.50	94.50	28.50	1.24	0.216
BMI [kg/m2]	109.00	81.00	15.00	2.35	0.019
Experience [years]	61.00	129.00	25.00	-1.53	0.127
Analysed variables	Sum of ranks boys (14 years)	Sum of ranks girls (14 years)	U	Z	P
MMSH [N]	185.00	68.00	2.00	3.81	0.0001
MLPH [mm]	173.50	79.50	13.50	3.05	0.0023
Body mass [kg]	163.50	89.50	23.50	2.40	0.0165
Body height [m]	159.00	94.00	28.00	2.10	0.0356
BMI [kg/m2]	143.00	110.00	44.00	1.05	0.2934
Experience [years]	104.50	148.50	38.50	-1.41	0.1580
Analysed variables	Sum of ranks boys (15 years)	Sum of ranks girls (15 years)	U	Z	p
MMSH [N]	37.50	7.50	1.50	1.81	0.07
MLPH [mm]	39.00	6.00	0.00	2.19	0.03
Body mass [kg]	31.50	13.50	7.50	0.26	0.80
Body height [m]	37.00	8.00	2.00	1.68	0.09
BMI [kg/m2]	28.00	17.00	7.00	-0.39	0.70
Experience [years]	21.00	24.00	0.00	-2.19	0.03

MMSH – mean maximum strength of the right and left hand
MLPH – mean length of the phalanges of the right and left hand
BMI – body mass index

The analysis did not reveal significant differences in any of the variables ($p>0.05$). In the case of 12-year-olds, gender significantly differentiated only body height, i.e. boys were considerably taller. In the case of 13-year-olds, significantly higher values were obtained by boys in such variables as MMSH, body mass and BMI. Among 14-year-olds, boys had significantly higher values in such variables as MMSH, MLPH, body mass and body height.

The analysis of the results of 15-year-olds revealed significantly higher values for boys with regard to MLPH and experience.

Discussion

In Poland, studies on handgrip strength among children and adolescents training any sport are scarce. Our research included healthy children and adolescents not uniform in terms of gender, age and training experience.

Numerous foreign researchers [14-16] proved that general anthropometric parameters such as body mass and height as well as age correlate significantly with handgrip strength in the case of children and adolescents.

The study by Visnapuu [17] carried out in Estonia on nearly 200 boys training basketball and handball revealed a significant correlation between the obtained results of handgrip strength test and age, body height, body mass and BMI. An important conclusion drawn from this study is that general parameters related to body dimensions influence handgrip strength to a larger extent than hand-specific parameters such as finger span, finger length and finger circumference. However, there is quite a strong correlation between body height of Estonian players and their finger length and handgrip strength, which helps them outperform their opponents in sports games. The results of our study are in line with the findings of the studies mentioned above.

In the research by Omarabc [18] carried out in 2015 on 525 children from primary schools in Rijad in Saudi Arabia, handgrip strength increased together with age in both genders. However, higher results were achieved by boys. The comparison of the results of 6-year-old boys and girls revealed that handgrip strength among the boys was higher by 6.5% than among the girls. In the group of children aged 7-9, the difference between genders was at the level of 14-18 %, while among children aged 10-12, boys were nearly 15% stronger than their female peers. No significant differences in handgrip strength were noted between left-handed and right-handed children, which is in line with the results obtained in our study. The conclusions drawn by Omarabca [18]

differ from the conclusions formulated by Häger-Ross [15]. His research results revealed that right-handed children develop greater handgrip strength in their right hand, while in the case of left-handed children, handgrip strength both in the left and in the right hand had no statistical significance.

The results of handgrip strength test are much lower among children from Saudi Arabia than among children from European countries [15]. It may be caused by socio-cultural differences such as race, ethnic origin and state of nutrition. Previous research that was also carried out in Saudi Arabia [19,20] revealed that Saudi children had lower values of body weight and body height than children from Europe.

Handgrip strength of Saudi Arabian boys younger than 9 is similar to the results of their counterparts from Sweden and the USA but lower than in the group of children aged 10-12 [21]. In the examined group of handball players, the results of handgrip strength in girls were between 74 N and 343 N, while in a similar age group (6-12 years) of girls from Saudi Arabia, the results were between 77.6 N and 208 N.

In our study, we found a strong correlation ($p<0.001$) between handgrip strength and age both among girls and boys. The research by Svensson et al. [22], who measured handgrip strength among children and adolescents aged 6, 10 and 14 with the use of Grippit dynamometer, confirmed the obtained results.

However, the research conducted by Molenaar [23] among children and adolescents in three age groups (4-6, 7-9 and 10-12 years) with the use of the Lode dynamometer and the Martin vigorimeter revealed that the participant's age did not exert a significant influence on the obtained results. When examining Swedish children and adolescents aged 4-16, Häger-Ross [15] revealed that the greatest increase in handgrip strength occurred at the age of 13. In turn, Rauch et al. (2001) revealed that the maximal increase in strength occurred later, i.e. at an average age of 14.1.

Visnapuu [17] found that maximal handgrip strength increased in each successive age group. The study participants demonstrated the highest increase in strength at the age of 14-15, which may be related to a quick increase in body height and mass at this age. In turn, the studies by Omarabc [18] and Häger-Ross [15] revealed a considerable increase in handgrip strength in a younger group (10-12-year-olds), which may occur at the beginning of the puberty period which, in turn, has a strong influence on an increase in the developed strength.

In the study by Visnapuu [17], maximal handgrip strength is significantly related to the length of fingers in boys from the age groups of 12-13-year-olds and 16-17-year-olds. It seems interesting that after calculating correlations with body mass, it appeared that they were not significant only in the case of age groups of 12-13-year-olds and 14-15-year-olds. In our research, the length of the phalanx of the middle finger considerably affected the level of handgrip strength ($p<0.001$).

In the literature, there are few publications regarding the effects of hand dimensions on handgrip strength. In the study by Häger-Ross [15], the distance from the wrist joint to the tip of the middle finger was carefully measured. The results of this study confirmed our results. The above-mentioned distance is an important parameter which improves handgrip; however, the results were higher in male groups than in female groups. In turn, contrary findings were revealed in the study by Nicolay and Walker [24], who carried out research on 80 students aged 19 to 29. The examined group included individuals who did not do any sports and persons who played volleyball, basketball and wrestling professionally. These are sports in which handgrip is used. The results obtained by Nicolay and Walker proved a significant correlation between hand anthropometric dimensions and handgrip strength.

The results of the study confirm previous findings of España-Romero V. et al. [25], who revealed insignificant differences in handgrip between test results and repetition values. In turn, Clerke [26], who examined 228 adolescents aged 13 to 17, revealed slight but statistically significant correlations ($p<0.01$) between the number of repetitions and the obtained handgrip strength result.

Conclusions

As a result of the research and the statistical analysis of the obtained results, the following conclusions and final remarks were formulated: general anthropometric dimensions such as body height, body mass and age significantly correlated with handgrip strength in the examined group of children and adolescents. Handgrip strength significantly depended on the participants' gender.

The given values of handgrip strength will help coaches and therapists to compare the results of children and adolescents according to age, gender and body dimensions in order to monitor strength and to plan strength training programme in handball. In the future, research in this field may be broadened by such anthropometric measurements as finger length, finger span and finger circumference. The analysis of these values could provide new information related to kinematic and dynamic abilities of upper limbs.

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