Normative Reference Standard for Handgrip Strength among Adolescent Students in South Punjab Pakistan: A Cross-Sectional Study

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ABSTRACT

Purpose: The study provided the age and gender-specific normative standard by using LMS technique and comparison with international reference values for the muscular strength by hand grip among adolescents of South Punjab, Pakistan.

Design/Methodology/Approach: A cross sectional descriptive research design was adopted, 60 public high school with 2970 students aged 12-16 contributed. Hand grip strength was measured using (GRIPX Digital Hand Dynamometer). LMS method was used for calculating reference norms. Age and gender-specific smoothed percentile curves P5th to P95th were acquired for hand grip strength.

Findings: The results revealed that the boys were higher in muscular strength than their counterparts, South Punjab's adolescents were found lower in strength than the compared adolescents. Around 40% of the population is falling in the poor and very poor zone.

Implications/Originality/Value: The current study presented the foremost age and gender specific hand grip strength percentile curves and provided the health benefit zones for the adolescent of South Punjab.

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Introduction

Grasping or throwing is an ability of humans which is based on the strength of the hand (Khan et al., 2019). The hand grip strength which is considered as the most commonly used as well as

least invasive measure to predict the overall muscular strength and is usually used to gauge the strength and fitness of a person. Hand grip strength is useful in assessing the hand functions of person (Jawaria, 2018). Hand grip strength is an indicator that specifically tells us about the strength of the upper extremity and predicts the overall muscular strength too. Muscle strength is an indicator that depicts the health especially in youth population (Ekelund et al., 2007) and work as an independent risk factor when it comes to mortality rate of adults (Garcia-Hermoso et al., 2018). There are many techniques available for measuring the overall physical fitness and muscular strength, but they require intensive and long duration procedures. On the other hand, hand grip strength test is valid, reliable and feasible to measure muscular strength of body with a single dynamometer instrument.

Grip strength has a core importance in clinical studies. there are several clinical outcomes such as cardiovascular diseases and its related mortality that is linked to be predicted health related risk by hand grip strength (McGrath et al., 2020). Not only this but also a sequential decrease in handgrip strength is a predictor of stroke. However, handgrip strength cannot be used to determine the cardiovascular functions (Fredriksen et al., 2018). It is observed that cardiac patients have a decrease in muscle strength and in turn decreased handgrip strength. Hand grip strength of the dominant hand is found less in cardiac patients when compared with normal individuals of the same age (Mirza et al., 2020). Thus handgrip strength demonstrates starring role in determining the health status of any individual as well (Musalek et al., 2017).

Obesity has become dangerous phenomena and created emergency situation in modern era. Almost every country whether it is developed or developing country are facing the pandemic of obesity especially at younger population. Individuals having BMI greater than 25 have increased risk of developing various diseases. hand grip strength is now considered as a valid indicator of accelerating aging process in humans because obese persons have high cortisol (aging hormone) that cause them to have a low muscle strength and that is indicated by a decrease in hand grip strength (Mirza et al., 2020). Physical activity has been found a resistance against obesity and in prevention of several other diseases (Lavie et al., 2019). There is an important correspondence between level of physical activity as well as BMI with the hand grip strength of adolescents that has been stated in studies (Mirza et al., 2020, Tahir et al., 2021). Physical activity has a positive effect in increasing hand grip strength and effect of BMI on hand grip strength too (Mirza et al., 2020, Tahir et al., 2021, Rafique et al., 2014).

Age specific and gender specific reference values have already been published globally (Catley, 2013, Peterson, 2015). However, a large amount of handgrip publications is found in the USA, Europe, Australia other Asian country like China and Korea and other pacific or more in developed countries (Perna et al., 2016, Laurson et al., 2017, Cohen et al., 2010, Catley, 2013, Sun et al., 2020, Lee et al., 2017). In contrast, there is scarcity of reference values of handgrip strength as well as other fitness components indicators into developing or below developing countries, which makes impossible to evaluate the health or fitness indexes especially at young aged adolescents (Ruiz et al., 2008). That is why the normative percentile values of hand grip strength have been worked as a framework for the classification of fitness levels for adolescents. Less than 20th centile is “very low/poor”; from 20th to 40th centiles as “low/poor”; from 40th to 60th centiles as “moderate”; from 60th to 80th centiles as “high/good”; and when it is above the 80th centile, it is “very high/good” (Catley, 2013, Tomkinson et al., 2018). It is stated that if level of physical fitness is below the fifth centile then there is an increases risk of development of CVD in future times (Twisk et al., 2002).

From the perspective of public health and construction of reference values of handgrip strength to identify the levels of adolescent’s handgrip strength, hand grip strength dynamometer is found to be inexpensive, portable and reliable instrument. WHO has diverted its attention towards this

growing issue and is encouraging to increase the level of physical activity and physical fitness to have a good muscular strength and hand grip strength is the best measure to assess (Fühner et al., 2020). This marks the importance of hand grip strength. But to dismay, Pakistan is one of the countries where this direct domain is highly neglected. There is no even single research done on 12 to 16 years old adolescents of South Punjab, Pakistan. Therefore, it became the prime focus of study to know the normative value of hand grip strength in this region and also compared the current calculated reference values with published international studies.

Physical fitness in early age plays an important role in the health and fitness of adolescents as well as in adulthood. Developed as well as developing countries are keeping eye strictly on adolescents' fitness as this age group is really important in the term of physical and mental development of individual. Physical fitness criteria have already been studied globally especially for adolescents to minimize the high rate of obesity which has become a leading phenomenon of the modern era. The importance of defining a normative value lies the fact that it helps in assessing the current status and making the comparison among the diverse age and gender specific populations of different countries but no such effort has been made in South Punjab Pakistan. Current study had on two objectives firstly, construction of age-gender-specific normative reference values of hand grip strength by using LMS technique for the adolescents of south Punjab Pakistan. Lastly, it compared the hand grip strength with the other published reference values of hand grip strength and developed health benefit zone followed by normative cut off values similar to the USA, European and Asian studies for the adolescent population of South Punjab (Perna et al., 2016, Laurson et al., 2017, Cohen et al., 2010, Catley, 2013, Sun et al., 2020, Lee, 2017). This was the first study in South Punjab Pakistan which presented the handgrip strength normative reference values by using LMS technique (Cole, 1990).

Methods

It is a Cross-sectional study. Sampling was done by Stratified random Sampling. The main Strata is South Punjab which has further divided into three administrative division as Stratum and three most populous district (Multan, Bahawalpur, D. G. Khan) were selected for study representation. Randomly selected sixty (12 % of high schools from three districts of South Punjab, Pakistan) public high schools were included for data collection according to Education Department official statistics (Punjab Government School Information System, 2020). Sixty schools were further distributed equally among the three stratum as Multan 20 (33.33%), Bahawalpur 20 (33.33 %) and D. G. Khan 20 (33.33 %). For the determination of sample size current study opted the equation used by Suresh et al., 2012 for the sample size calculation (Suresh et al., 2012). Consequential, the sample aged 12-16, total of 3012 school adolescents were selected randomly out of which 50% were boys and 50% were girls from the South Punjab Pakistan. Initially, a total of 3012 participant's measurements were obtained however, forty one participants were excluded from Sample due to outliers. Inclusion criteria for participants was that student should be physically and mentally fit. The exclusion criteria was based on the report of any type of dysfunction that can limit the physical activity e.g. any disease or physical or mental disability.

Ethical Approval and Consent

Trained research assistants from Bahauddin Zakariya University, South Punjab, Pakistan were assistants for data collection under the supervision of senior member of the team. The consent was taken and hence the participants were allowed to withdraw any time from study. For that written approval for holding this research was achieved by education authorities and school Principal. Verbal consent from guardian and students were taken. The study was conducted according to ethical standards in sport and exercise science research (Harriss, et al., 2019). The study was approved by the research ethical board of faculty of sport science, school of kinesiology, Shanghai University of Sport (SUS), Shanghai, China.

Procedure

Anthropometric Parameters

Age (years), gender, height, weight, and BMI (kg/m²) etc. were measured and saved. These anthropometric measurements were taken when students were barefoot as well as wearing a light cloth. A portable electronic scale was used for the measurement of body mass. The status of Body mass was classified using the Centre of disease control (CDC) age specific and gender-specific thresholds (CDC, 2017).

Handgrip Strength

A standard adjustable digital dynamometer (GRIPX Digital Hand Dynamometer) was used for the measurement of handgrip. A brief demonstration was given to students and verbal instructions were also provided to explain the test, and if there was a need, the students were helped in adjusting it to their hand size as was decided by our predetermined protocols (CDC, 2017).

The dynamometer was calibrated by us according to the already known body masses in a periodic manner and there was no drift observed. Handgrip strength was observed in the subject when he was in a standing position with the shoulder in an adducted position and was neutrally rotated as well as the arms being parallel but not in touch with the body interface. The students were asked to squeeze the handle for a maximum of three to five seconds. There was no verbal encouragement allowed during the test time. There was a two trials period allowed for each of the limb. The cumulative average was calculated for every peak grip strength (kg) that was recorded and that average was then applied. So, the values of hand grip which we are demonstrating in this study are as a result of combination of the values of left hand as well as and right-handed subjects. The results were observed irrespective of the dominance of left or right hand. The handgrip strength recorded the peak grip strength (kg) (CDC, 2017).

Data Analysis

After raw data acquisition, unique identification codes were assigned to every individual, as for the area status and the gender (Male = 1 and Female = 2). Data was entered in the sheet of Microsoft excel. The Current study adopted a cut-off of SD- score (Z-Score) and this study agreed ± 5 Z-scores cut-off points to identify outliers. Finally, a sample of 2970 (approximately 98%) participants was subjected for further statistical analysis. Descriptive and inferential analysis, percentages (%), frequencies, Mean, and standard deviation of variables were analyzed. To check the normality of data (Kolmogorov-Smirnov test) was also applied. The mean differences of gender-wise and which were calculated via a non-parametric Mann-Whitney U test Chi-square test was also applied to know the association of age-gender with indicators. The LMS method was used and L (γ lambda), M (μ) and S (σ sigma) curves were made to obtain the percentile value of muscular strength indicator of health related physical fitness (Cole, 1990). In this regard, LMS method was adopted and generated in R statistical software version 3.0.2. descriptive and inferential analysis Statistical Package for the Social Sciences (SPSS) version 21.0. The value of $P < 0.05$ was set as a significant.

Results

Table 1 Demographic analysis age and gender specific

Indicators	Boys	Girls	Total
Age-groups (years)			
12 N (%)	291 (19.7%)	299 (20.24%)	590 (19.9%)
13 N (%)	295 (19.97%)	298 (20.17%)	593 (20.0%)
14 N (%)	298 (20.17%)	296 (20.04%)	594 (20.0%)
15 N (%)	298 (20.17%)	300 (20.31%)	598 (20.1%)
16 N (%)	295 (19.7%)	300 (20.31%)	595 (20.0%)
Area			

Multan N (%)	495(33.51%)	498(33.71%)	993 (33.4%)
D G Khan N (%)	491(33.24%)	498(33.71%)	989 (33.3%)
Bahawalpur N (%)	491(33.24%)	497(33.64%)	988 (33.3%)
Total	1477 (100%)	1493 (100%)	2970 (100 %)

Note: The data was presented as N: Number of sample and percentage %.

Sample population distribution for each age category is presented in Table 1. There is equal participation from each group in a category whether it is age related, gender based or area wise.

Table 2 Gender Specific Anthropometric Component of Participants

Component	Total		Boys		Girls		P-value
	N	M±SD	N	M±SD	N	M±SD	
Age (years)	2970	14.01±1.41	1477	14.01±1.41	1493	14.00±1.41	<0.001
Height (cm)	2970	159.53±10.51	1477	160.50±11.50	1493	158.57±9.34	<0.001
Weight (kg)	2970	43.00±9.10	1477	45.02±9.78	1493	41.00±7.89	<0.001
BMI (kg/m ²)	2970	16.80±2.67	1477	17.30±2.41	1493	16.29±2.82	<0.001
HGS (kg)	2970	24.39±13.36	1477	31.81±14.85	1493	17.06±5.39	<0.001

Note: The data was presented as mean ± standard deviation, HGS (kg): Hand Grip Strength (kilograms)

Table 2 shows mean age of boys and girls was 14.01±1.41 years (P <0.001). The average height of the population was 159.53 ±10.51cm (P <0.001). The average weight of boys and girls was 43.00±9.10 kg (P <0.001). Mean BMI of both gender found 16.80±2.67 (P <0.001). However, mean anthropometric variables, i.e., height, weight, BMI were higher in boys than in girls. While talking about handgrip strength results showed that 24.39±13.36 kg (P <0.001) averagely. Whereas results reflected that boys handgrip strength was found almost doubled than girls as 31.81±14.85 kg than 17.06±5.39 kg respectively.

Table 3 Hand Grip (kg) Percentile by Age and Gender in Adolescents Aged 12-16 from South Punjab

Age	N	M	P 5	P 20	P 40	P 50	P 60	P 80	P 95
Boys									
12	291	22.53	9.38	14.64	19.83	22.53	25.50	33.36	46.77
13	295	25.77	12.67	17.85	23.03	25.77	28.83	37.21	52.50
14	298	29.00	15.78	20.99	26.21	29.00	32.15	40.97	57.92
15	298	32.24	18.69	24.02	29.37	32.24	35.50	44.70	62.96
16	295	35.47	21.30	26.89	32.48	35.47	38.86	48.49	67.72
Girls									
12	299	14.12	8.30	11.05	13.12	14.12	15.17	17.77	21.77
13	298	15.01	8.49	11.27	13.80	15.01	16.28	19.36	24.00
14	296	16.48	8.65	12.10	15.09	16.48	17.92	21.36	26.36
15	300	18.16	9.90	13.76	16.79	18.16	19.55	22.80	27.32
16	300	20.18	10.78	15.30	18.68	20.18	21.68	25.11	29.75

Note: N, Number of participants; M, median

Figure 1 Hand grip strength (kg) percentile curve for the South Punjab.

The Smoothed LMS curves (for the 5th, 20th, 40th, 50th, 60th, 80th and 95th centiles) for the handgrip strength of boys and girls are presented in figure 1 and corresponding numeric are presented in table 3 and figure 1. It is noticeable from the centiles that the boys of every age showed a better hand grip strength test than girls. For boys and girls, the value of 50th centile of

handgrip strength was ranging from 22.53 to 35.47 kg and 13.12 to 20.18 kg respectively. Moreover, it was observed that there was approximately 3 to 5 kg average annual increase was detected in boys and girls. In both boys as well as girls, it was observed that the muscle strength increased across the age range, however the increase in performance was observed to be marked between 14 and 15 years.

Figure 2 Percent of Adolescents by hand Grip Strength Health benefit zone by age and Gender.

Figure 2 presented that boys at aged 12 and girls at aged 15 had same maximum percentage as 22.67% in very poor category respectively. The maximum percentage of the medium category population was found at ages of 15 (33.22%) and 16 years (24.67%) between boys and girls respectively. In very good category boys at age 14 and girls at age 12 as well as 13 had almost

identical percentages as 21%. Thus, boys seemed better than girls in good and very good category muscular strength, but both the boys and girls need to work hard for the improvement in their muscular strength as well as overall healthy life.

Comparison with foreign normative references

Table 4 Hand Grip (kg) Comparison of P50 between present studies and other published studies

Age (years)	Present Study	Laurson et al., (2017)	Sun et al., (2020)	Catley et al., (2013)	Ramírez et al., (2017)	Lee, S. (2017)
Boys						
12	22.5	22.6	23.9	22.7	17.5	-
13	25.8	28.4	27.8	25.8	21.1	24.8
14	29.0	34.6	31.7	30.7	23.8	29.5
15	32.2	39.5	35.3	36.5	28.5	33.2
16	35.5	42.9	38.3	-	31.1	36.0
Girls						
12	14.1	20.6	19.9	21.4	18.1	-
13	15.0	24.6	21.6	23.6	19.5	20.4
14	16.5	27.1	23.7	25.4	21.9	21.6
15	18.2	28	24.5	26.9	21.5	22.2
16	20.9	28.2	25.8	-	22.7	22.3

Note: – Not reported

Figure 3 HGS (kg) Comparison of P50th between Present Studies and Published Studies

Table 4 and figure 3 shows the normative reference values (the value of 50th centile) of handgrip strength that was also measured in (kg) referenced from different studies with respect to age and gender. The European, Australian, Chinese, Colombian and Korean adolescents showed a score that is comparatively better than Pakistani adolescents according to 50th centile values, except for Colombian boys at all given years of age (Laurson et al., 2017, Catley, 2013, Sun et al., 2020, Ramírez-Vélez et al., 2015, Lee et al., 2017). In contrast, Pakistani male children scored higher than their Colombian counterparts. However, Colombian girls scored higher hand grip strength than Pakistani girls of all ages stated. Muscular strength of south Punjab Pakistan's Adolescence is found higher in boys than girls. Moreover, Muscular strength of Pakistani Adolescence on basis of age and gender is lower than the most of other nations.

Discussion

Anthropometric measures are important while discussing handgrip strength. Because Anthropometric measures like height weight and BMI are important indicators of hand grip strength as stated in a Korean study (Lee et al., 2017). Moreover, anthropometric characteristics can help in selection and application of appropriate sports training design as well as exercises for the rehabilitation and treatment of people having poor hand grip strength or other hand related deformities. Current study presented all the mean anthropometric variables, i.e., height, weight, BMI were higher in boys than in girls and the same was observed in similar study of Pakistani population where the anthropometric measures were higher in boys than girls (Tahir et al., 2021).

Meanwhile, the mean of the handgrip strengths of south Punjab Pakistan's adolescents was marked among boys than girls. A study also concluded that value of the mean of the handgrip strength was significantly marked in boys than girls (Jawaria, 2018). A research study conducted in city of Karachi, Pakistan concluded that the muscle strength as well as hand grip strength was low in females as compared to males (Mirza et al., 2020). A study of Pakistani population in as well as Columbian are also in congruence and also showed that hand grip strength in females is lower than males, this also demonstrates that low females have low muscle strength as compared

to males regardless of age specification (Jawaria, 2018, Ramírez-Vélez et al., 2015). These sex related differences are evident in many other studies as well (Laurson et al., 2017, Cohen et al., 2010, Ramírez-Vélez et al., 2015). The average value of hand grip strength in current study is 31.81 ± 14.85 kg while, another Pakistani study's hand grip strength outcome was 30.75 ± 14.35 kg which is in congruence with the current findings (Mirza et al., 2020).

Current study also made comparison of the values of P50th percentile of South Punjab's adolescents with the values of P50th percentile of other selected international studies. Overall, European, Australian, Chinese, Colombian and Korean adolescents showed scores were more marked than Pakistani children at the 50th centile (Laurson et al., 2017, Catley, 2013, Sun et al., 2020, Lee et al., 2017, Ramírez-Vélez et al., 2015). In contrast, Pakistani children of male sex scored higher than their Colombian counterparts. However, Colombian girls also scored higher than Pakistani girls of all ages stated. Another comparison study showed a comparison of the values of the hand grip strength of the student of Tsinghua University Beijing and University of Sindh Pakistan, that showed hand grip strength of female Chinese students was higher than female Pakistani students (Rafique et al., 2014). Our results are in congruence with another Pakistani study that also concluded that hand grip strength of Pakistani adolescents is less than consolidated values by 30.8 % in males and 24.1 % in females (Jawaria, 2018). The reason for the difference with respect to the age and gender is usually interpreted by individual differences for instance physical differences, difference in muscle mass, total body weight, and stature (Sherriff et al., 2008). Moreover data from a recent study in Pakistan depicted an overall increase in screen time among youth, which might be accounted for low levels of handgrip strength as literature supports that low physical activity and high sedentary behaviour may affect the strength of an individual (Ijaz et al., 2020).

Results of Columbian adolescent's hand grip strength revealed that more percentage of boys and girls of 12 to 16 years of age were in the category of "Need improvement" and another study conducted in USA reported that a significant number of 12 to 16 years old boys were found in "Need improvement" zone than girls as the current study also confirmed these findings after having the similar results (Ramírez-Vélez et al., 2015). More percentage of girls were in the excellent category of health benefits zone in this study which was based on Columbine adolescent of age 12 to 16 years as similar to current study which also reflects that the adolescent girls of 12 to 16 years old were found more in numbers than boys in good or excellent category (Ramírez-Vélez et al., 2015). Hence, these research findings are also verifying our result and hence strengthening the results of our study.

Current study successfully calculated the normative reference values of hand grip strength of adolescents of south Punjab Pakistan by using LMS method. Additionally, also provided the health benefit zone for adolescents to better understand their current level to make further improvement of muscular strength as well as overall fitness.

Physical educators are requested to monitor and form policies to escalate vigorous physical activity levels among youth. Thus milestone can be achieved by increasing sports at school and club organizations (Pozuelo-Carrascosa et al., 2018). So the schools are acknowledged as potential setting to improve healthy lifestyle among children and adolescents (Escalante et al., 2011).

Conclusion

Current study provided the age and gender specific anthropometric measurements and BMI of adolescents of South Punjab, Pakistan's boys were found having higher values of BMI. Moreover, hand grip strength was higher in male at each percentile level and age group than girls. This demonstrated boys had higher muscular strength with respect to each age group than

girls. The comparison with international standards showed that hand grip strength of Pakistani children is lower than many other countries including China, USA, Europe and Australia. As hand grip strength is considered as a marker of muscular strength indicator of health related physical fitness, so this is creating an alarming situation for Pakistani adolescents. The government as well as responsible institutions should focus more on the promotion of physical activity, and healthy life style in adolescents at schools specifically.

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