ORIGINAL ARTICLE

NORMATIVE REFERENCE STANDARD FOR CORE MUSCULAR ENDURANCE OF ADOLESCENT 12–16 YEARS FROM SOUTH PUNJAB, PAKISTAN: A CROSS-SECTIONAL STUDY

Syed Muhammad Zeeshan Haider Hamdani[1,2], Jie Zhuang[2], Syed Ghufran Hadier[1,3], Wang Tian[2], Syed Danish Haider Hamdani[4], Shaista Shireen[4], Syeda Urooj Fatima[1], Sadaf Kazmi[5]

[1]Department of Arts & Social Sciences, Department of Sports Sciences, Bahauddin Zakariya University, Multan, Pakistan. [2]Research Scholar, Faculty of Sport Science, School of Kinesiology, Shanghai University of Sport, Shanghai, China. [3]School of Physical Education, Shanxi University, China, [4]School of Physical Education, Beijing Sport University, Beijing China, [5]Department of Education, Multan, South Punjab, Pakistan

Background: Core muscular endurance has been a part of the investigation for several decades in clinical and non-clinical settings. Current research had three objectives as; firstly, the prevalence estimation of muscular endurance; secondly, to provide the normative reference standards of plank test by Lambda (λ), Mu (μ) and Sigma (σ) 'LMS' technique and lastly, to provide the status of healthy and un-healthy zones of aged 12 to 16 years old adolescents of South Punjab for the very first time. **Methods:** This study is a cross-sectional descriptive research design with a total of 2970 students aged 12–16 contributing almost equally in numbers from 60 public high schools. Muscular endurance was estimated from Plank to Fatigue (PTF) test. LMS method/technique was deployed to acquire reference norms for muscular endurance by the plank test. **Results:** The plank endurance test calculated age and gender-specific smoothed percentile curves (5th, 20th, 40th, 50th, 60th, 80th, and 95th). Overall, results reflected that boys were found higher in average plank values than their counterparts; meanwhile, the international comparison showed that current outcomes are similar to the preceding studies. The result showed that 60.1% of the population is falling in the poor, medium and very poor categories. **Conclusion:** The present study exhibited the earliest age-gender specific plank endurance test normative reference values, percentile curves and health-benefit zones of 12 to 16 years old adolescents of South Punjab Pakistan.

Keywords: Human health, Core muscular endurance, Normative reference standard, Percentile curves, Health-related physical fitness

Pak J Physiol 2022;18(1):3–8

INTRODUCTION

Researchers, scientists, coaches, athletes, and practitioners have intensively scrutinized core muscle endurance in recent years. The abdominal "core" provides all appendicular body movements and stabilizes the lower limb, upper limb, abdominal structure, hips, and spine.[1] Without any muscle attachment bare spine cannot bear the compressive load.[2,3] According to Santos MS (2019) definition of Core muscular endurance has been derived as the ability of the core or trunk muscles to produce and maintain force against a specific position for a maximum period of time.[4] Particularly, core muscular (trunk and hip muscles) endurance is essential for exercise and sports training because the core plays a vital role in transferring power to the appendicular skeleton. Core endurance or core stability is often tested in several capacities, for instance, pre-screening for risk of injury assessment, exercise or rehabilitation prescription or prevalence estimation health-related physical.[5,6] Musculature traversing and subsidizing these regions is related with a core comprising internal obliques, external obliques, transverse abdominis and rectus abdominis. Moreover, the latissimus dorsi, pectorals, hamstrings, quadriceps, iliopsoas, trapezius, hip rotators, and glutei structure core muscles.[7] Every segment of the human body is vital in accordance with its functioning and capacity, but the core has the most imperative position because not only does exercise or intense sports require core strength, but one's daily living is impossible without core stability.

Currently, measuring abdominal endurance and strength or assessing core stability isokinetic testing is considered the most advanced and standardized way to obtain reliable and accurate outcomes.[8] Though, isokinetic testing is expensive as well as entails large machines, specific physical environment (labs) and specialized technicians, which is good in clinical settings but very impractical for the non-clinical settings.[9]

Muscular assessment is usually conducted in two ways: one is muscular endurance, and the other is muscular strength.[10] Muscular endurance is determined by the ability of a muscle to sustain a certain level of force consistently for a maximum period of time, whereas muscle strength is explained as the maximum force generated by a muscle or group of muscles against a stimulus at once a short period of time.[10]

Additionally, literature has already recommended that operationally muscular endurance is more important in aiding core musculature than muscle strength, so it is more obvious to stay focused on

muscular endurance.[11] In the past, to enhance the strength level of an athlete, to acknowledge the abdominal endurance or performance assessment, non-clinically sit-ups and curl-ups have been utilized by researchers, trainers and coaches. However, literature has also indicated that sit-ups and curl-ups might predict muscular strength or power, but for muscular endurance, these tests are less indicative.[11] Restrained feet require hip flexor to get activated while performing sit-ups which ultimately assist in sit-up motion. There are quite a lot of apprehensions regarding sit-up test gesticulation, which involves activation of hip flexor and the alternative lumbar flexion patterns with hyper lordosis, which causes extra pressure on lumber region discs. Additionally, it is also hypothesized that sit-up movement increases the injury risk.[11] While regarding administration, cost and time effectiveness sit-up and curl-up, both tests are not easy to administrate and effective in terms of money and time. These tests include a high level of supervision and training for the administrators as well as test-takers to maintain reliability and validity.[12] Though both sit-ups and curl-ups are widely used among physical educators and coaches; there is still inadequate data or reference values published on these tests.

Therefore, aiming to assess the muscular endurance literature has a penalty of data on early described drawbacks of the isokinetic testing or core endurance assessment from sit-ups and curl-ups.[13] Regrettably, the concerns (administrative training, cost-effectiveness, time-effective, physical space effective, risk of injury, reliability and validity) as well as criticism regarding sit-ups and curl-ups mentioned and described previously there is a dire need to find out other reliable tests which could address the issues positively to assess the core muscular endurance specifically.[11] Conclusively, going through the literature, the plank test is not as difficult to administrate, a reliable tool to assess core muscular endurance specifically, cost and time effective, and has less risk of injury among all available tools.[14] So, the current study adopted an unlimited time plank or plank to fatigue (PTF) test to measure the core muscular endurance. To achieve the study's objective, a plank test was applied on the 12 to 16 years old adolescents of South Punjab to assess core muscular endurance and further construction of age-gender specific normative reference standards by LMS technique school-aged adolescents.

METHODOLOGY

A cross-sectional study design was conducted to obtain the study's objectives, followed by stratified random sampling. South Punjab was selected as strata, out of which three strums were created as Multan, Bahawalpur, DG Khan. The main strata (South Punjab) hold 485 public high schools, out of which 12% (60 schools approx.) were selected randomly. The further selection of the schools was made among each strum equally as 20 public high schools from Multan, Bahawalpur and DG Khan.

The preliminary study of plank testing on school-going adolescents aged 12 to 16 from South Punjab represented the study as the sample. As suggested by the current literature study used the same equation for the acquisition of sampling size.[15] According to sample size calculator equation with values of P= 0.4 (40%), Q= 0.6 (1-P), Z-Score= 1.96 at 5% significance level, e= 0.0175 level of precision and D= 1 (D is the design effect) resulted 3010 sample size to achieve the research objectives. Hence, 3012 male and female adolescents were included with equal representation. Meanwhile, the 3012 adolescents were measured at that time, but forty-one participants were excluded due to outliers.[16]

The research design and methodology were prior approved by the research ethics committee of the faculty of sports science, school of kinesiology, Shanghai University of Sport (SUS), Shanghai, China. Written and oral consent was obtained before testing from administration, parents, and participants; hence, the participants were allowed to withdraw any time from the study. It was confirmed that all the participants were physically and mentally healthy with no previous record of having injury; additionally, no monetary compensation will be provided. Only the volunteered participants were included in the process of research. Trained research assistants from Bahauddin Zakariya University, South Punjab, Pakistan, were assistants for data collection under the supervision of a senior member of the team.

The anthropometric characteristics, i.e., height, weight, and BMI, were calculated by following international protocols of the Center for Disease Control, CDC, USA, 2012.[17] A stopwatch and a standardized gym mat were utilized as equipment necessary for the test conduction. Plank is an isometric exercise test conducted to assess core muscular endurance. Plank test protocol requires the participants to hold or maintain the static horizontal position as long as the participant can without being fatigued or injured easily. The prone static position was followed while measuring the core endurance as the participant was lying down on the yoga mat with both feet together with curled toes touching the mat. At the same time, the upper body was attached to the floor by elbows and forearm, mainly maintaining the distance between both arms just the same as the distance between shoulders, and hands separate against the floor mat and holding this position for as long as the participant can make it possible. Participants were further asked to maintain eye contact towards the mat floor, maintaining a neutral spine forming a perpendicular line to the parallel

smooth, straight under the shoulders. The plank position should be like a straight line from ankle to head. Every participant was provided with a chance of a 5 to 10 sec practice trial. Upon participant's discretion, the examiner provided a full set of instructions throughout the test and measurement procedure to better understand adolescents. An adequate time for rest was given to the participants between the practice trial and the actual test. The test was terminated, and time was recorded when the participant seemed fatigued or unable to uphold appropriate position or participant informed any illness or examiner observed any sign of illness.[18]

The current investigation applied quantitative research design and analysis techniques. For normality check of the data, Kolmogorov-Smirnov test was applied whereas, for uncovering the age-gender specific mean differences Mann-Whitney U-test a non-parametric test was adopted. Researcher for outlier's identification in anthropometric variables and plank test agreed ±5 Z-scores cut-off points.[19] Finally, 2970 sample sizes instead of 3012 adolescents were further analyzed after removing outliers. Acquisition of said purpose for descriptive and inferential statistics, percentages, frequencies, and mean and standard deviation of variables were formulated. The LMS method was applied and generated in R statistical software version 3.0.2.[20] To obtain the normative reference values and Lambda (λ), Mu (μ) and Sigma (σ) LMS curves of selected anthropometric and health-related physical fitness indicator core muscular endurance (plank to fatigue test) for the adolescent's population; for the sake of statistical analysis researcher adopted SPSS-21.

RESULTS

Table-1 represents the gender-specific average comparison of anthropometric characteristics. Results revealed that boys' mean values of anthropometric were relatively higher than girls. The average height (cm), weight (kg), body mass index (BMI), plank to fatigue test (PFT) of boys and girls was 160.50±11.50 and 158.57±9.34, 45.02±9.78 and 41.00±7.89, 17.30±2.41 and 16.29±2.82, 80.72±73.48 and 69.07±58.16 respectively. While making a comparison between gender and anthropometric characteristics, outcomes were significant (p<0.05) with the exception of age.

Table-2 and Figure-1 represent the normative reference values and percentile curves for the plank to fatigue (PTF) adolescents of South Punjab. The median (P50th) centiles for plank, the rise of 1.54 seconds in boys and 22.22 sec. in girls, was observed from 12 to 16 years of age. At the same time, the annual raise of plank seconds throughout the 12 to 16 years was detected 1 sec in boys and 3–8 sec in girls approximately. Overall the gender-specific comparison showed that the plank values of boys were higher than their counterparts except for 15 and 16 years old girls.

Figure-2 shows the comparison of p50th centiles for both genders with available research evidence found in the USA.[21] while comparison showed that 12–14 years old adolescents showed rising trend of plank values similar to the US boys and girls who also showed rising curves with some exception in US girls.[21]

Figure-3 represents the age and gender-specific plank estimate for the South Punjab school aged 12 to 16. The estimate presented the percentage of adolescents lying in each of the five categories ascribed as 21.72% were 'very poor', 17.34% were 'poor', 20.98% were 'medium', 17.47% were 'good' and 22.49% were 'very good'. Whereas, 'very poor' category represented 21.1% of boys and 22.3% of girls; 'poor' category represented 18% of boys and 16.7% of girls; 'medium' category represented that 19.4% of boys and 22.5% of girls; 'good' category represented that 21.3% of boys and 13.7% of girls; 'very good' category represented that 20% of boys and 25% of girls. At the age of 16, both girls' and boys' maximum percentages were found in the 'very poor' category as 37.67% and 24.75%, respectively. The maximum percentage in the 'poor' category was found as 22.48% boys at 15 years of age and 28.33% girls at 16 years of age. The maximum percentage in the 'medium' category was found as 25.76% boys at 16 years of age and 28.04% girls at 14 years of age. At 13 years, both girls' and boys' maximum percentages were found in the 'good' category as 25.42% and 28.04%, respectively. The maximum percentage in the 'very good' category was found as 31% boys at 14 years of age and 48% girls at 12 years of age.

Table-1: Anthropometric descriptive analysis gender specific

Component	Total (n=2970)	Boys (n=1477)	Girls (n=1493)	*p*
Age (Year)	14.00±1.41	14.01±1.41	14.00±1.42	0.927
Height (Cm)	159.53±10.51	160.50±11.50	158.57±9.34	<0.001
Weight (Kg)	43.00±9.10	45.02±9.78	41.00±7.89	<0.001
BMI (Kg/m^2)	16.80±2.67	17.30±2.41	16.29±2.82	<0.001
PE (Sec)	74.87±66.46	80.72±73.48	69.07±58.16	<0.05

Note: The data were presented as Mean±SD.
BMI: Body mass index; PE (Sec): Plank Exercise (Seconds)

Table-2: Plank Exercise (seconds) percentile by age and gender in adolescents from South Punjab

Age	n	M	P 5	P 20	P 40	P 50	P 60	P 80	P 95
Boys									
12	291	55.96	10.09	23.99	43.67	55.96	70.25	112.9	203.2
13	295	56.35	10.58	24.34	43.83	56.35	70.75	113.8	218.3
14	298	56.73	11.32	25.86	44.84	56.73	70.80	116.3	220.9
15	298	57.11	15.43	28.74	46.17	57.11	70.85	117.7	231.6
16	295	57.50	15.94	29.45	46.79	57.50	73.60	132.2	288.1
Girls									
12	299	43.76	9.49	21.85	36.82	43.76	50.81	68.76	97.3
13	298	45.40	11.41	24.41	37.24	45.40	55.40	84.09	138.7
14	296	50.59	13.21	25.16	40.81	50.59	62.77	102.8	201.5
15	300	57.72	18.83	31.36	47.51	57.72	70.67	115.6	244.6
16	300	65.98	20.30	34.93	53.94	65.98	81.23	133.8	280.5

Note: n= Number of the participant; M= Median

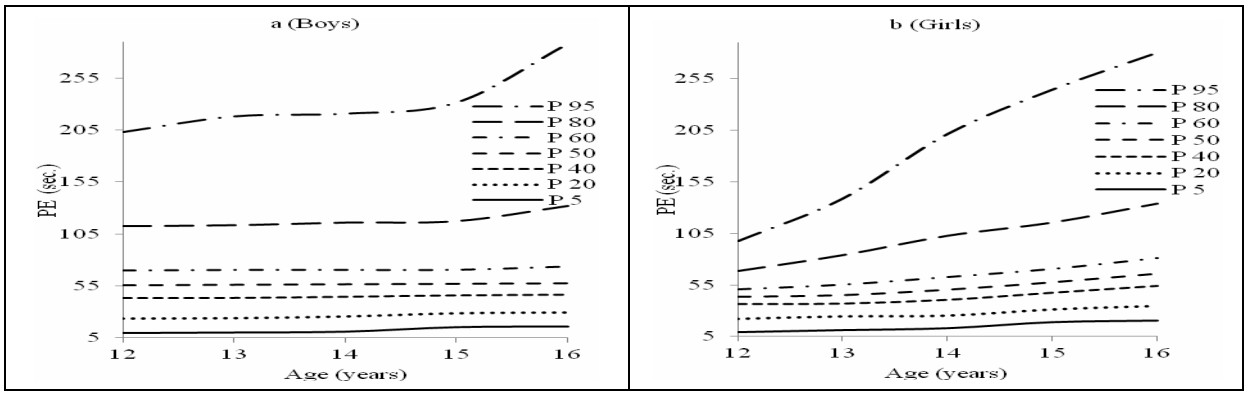

Figure-1: Plank Exercise (seconds) Smoothed percentile curves for South Punjab

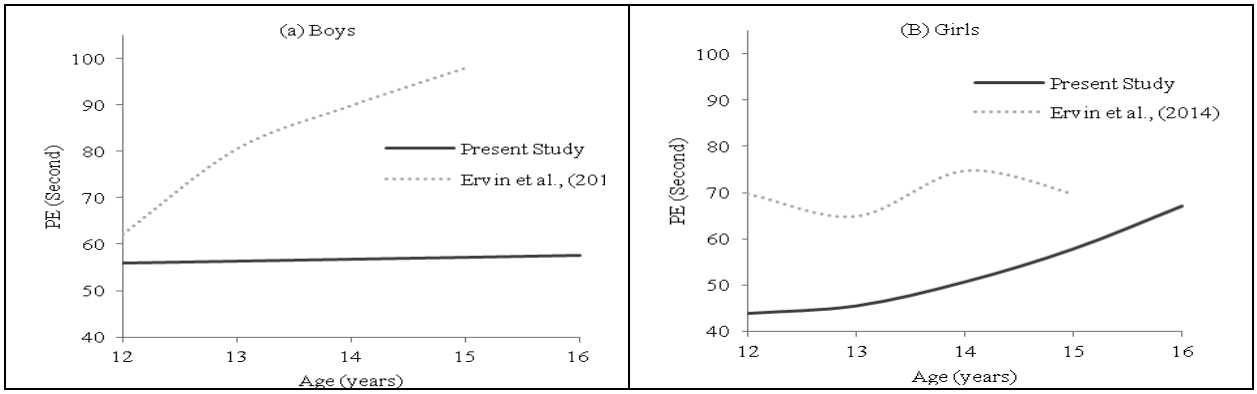

Figure-2: PE Comparison of P50 between present studies and other published studies

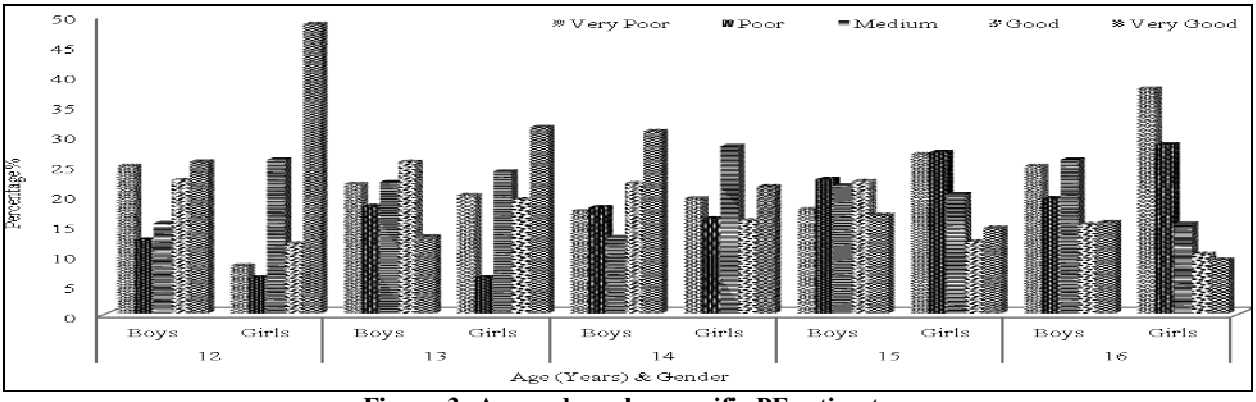

Figure-3: Age and gender-specific PE estimate

DISCUSSION

The current study is the pioneer study in Pakistan, representing the South Punjab school aged 12 to 16 years adolescents providing the average values of anthropometric characteristics and the normative reference values of core muscular endurance by plank to fatigue (PTF) test. The researchers all over accept that age, height, gender and weight standing are vital predictors of physical of adolescents and other age groups. Furthermore, anthropometric indicators provide help in the process of selecting and applying the proper sports training program and designing rehabilitation exercises. These predictors have a diverse impact on performance assessment depending on which test is performed. It is observed that performance predictors become robust with the increase in age until late adulthood, and it correlates with the current findings, which showed that core muscular endurance among adolescents also seemed mounting from age 12 to 16 among both boys and girls with few exceptions.[22]

Table-1 showed that boys dominated anthropometric measurements and core muscular endurance settings as having more plank seconds than girls. Age and gender differences tend to be connected with the physical transformation of bodies among adolescents during puberty. Scientists had ascribed that

the said differences in endurance are due to the change in anthropometric indicators and the volume of muscle mass during puberty.[23] Gender differences also play a significant role in strength and endurance among adolescent boys and girls even while selecting the physical activity, sport and exercise. Current findings are similar to previous studies as boys tend to have higher anthropometric values than girls.[24,25]

While discussing adolescents, as the weight of the adolescent's increases, they are found having problems in moving their bodies or performing tests accurately.[21] Research indicated that aerobic capacities, including core muscular endurance, were non-significantly decreasing with increased BMI among adolescents.[22] Another study concluded that obese and overweight children performed worse than the other normal children in sports.[26] The current research offered the average values of anthropometric variables, i.e., height, weight and BMI. It is found that BMI was higher in boys than in girls of South Punjab adolescents and other regions of Pakistan where the anthropometric measures were higher in boys than girls.[27] BMI is assumed as an important performance predictor in measuring core muscle endurance. While isometric plank testing or other isotonic exercises, obese adolescents are worse than normal adolescents due to excess volume of fats and body sizes which restricts their range of motion.[28]

The average plank test of boys and girls was 80.72±73.48 (seconds) and 69.07±58.16 (seconds), respectively. A consistent rising trend was found between the plank test and increased age (Table-2, Figure-1). Differences were found between both genders' performances compared with single years of age (Table-2). Notably, Figure-1 showed that during 14 to 15 years of age, both populations have slightly raised in the plank values. There might be several reasons for this variation that need further research specifically; the effect of physiological, psychological and socioeconomic determinants should be detected in this age group.[29] Overall, as literature predicted the plank values increased as the age increased among adolescents in South Punjab (Figure-1). The comparison with the only available P50th reference values on plank showed similarities in results. Figure-2 showed that boys dominated over girls with a higher centile of plank test percentiles. Though boys had higher values relatively than girls, it is worth noting that girls showed a higher trend of gaining core muscular endurance comparatively. As boys showed annual raise in plank approximately one second, girls tend to rise three to eight seconds annually, which is a remarkable finding.

While comparing 12 to 16 years old children's core muscular endurance with respect to age and gender showed significant results (p<0.05) among adolescents. The comparison of median centiles showed that US boys have a rising trend as the boys grow older from 12 to 15 years of age, whereas, girl's trend has variation. The results of the current study are similar to the US study.[21] The boys and girls of 12 to 16 years of South Punjab, Pakistan had lower percentile values than the USA adolescents.[21] The average plank test (sec) of boys and girls was 80.72 and 69.07, respectively. Whereas USA boys performed 91 seconds and girls performed 77 seconds.[30] However, the graphical trend showed that despite having lower values of South Punjabi girls than the US, the South Punjabi girls have a consistent rising trend than their counterparts.

Researchers have already used normative percentiles separated into a number of sections to classify health-related fitness levels among adolescents.[30, 31] Researcher for the acquisition of Plank test categories divided normative percentiles into 'Very Poor' >20th centile, 'Poor' 20–40th centile, 'Medium' 40–60th centile, 'Good' 60–80th centile and 'Very Good' <80th centile.[31] In the core muscular endurance testing, 41.3% of boys and 38.7% of girls were found in good and very good category (health benefit zone) whereas, 58.7% of boys and 61.3% of girls fall in 'poor', 'very poor' and 'medium' categories (unhealthy zones need for improvement). The majority of boys and girls need to improve their core muscular endurance to perform better in sports and daily life activities. Figure-3 showed that 21.1% of boys and 22.3% of girls are falling in a very poor category which is at risk in relation to core muscular endurance indicates, they might adopt several bad physical and health conditions. For the sake of better health of adolescents, current study outcomes might provide better insight and understanding regarding adolescents' existing core muscular endurance to embark on additional strategies for improving core muscular endurance and overall fitness and well-being in the future.

CONCLUSION

This study provided scientific evidence of normative reference standards to assess health-related physical fitness core muscular endurance of 12–16 years old adolescents. It provided an adaptable procedure that helps parents, peers, clinicians, researchers and physical educators to screen and formulate policies to escalate physical activity levels to avoid obesity and increase their core muscular endurance levels among adolescents.

ETHICAL APPROVAL AND CONSENT

The research ethics committee approved the study of the faculty of sports science, school of kinesiology, Shanghai University of Sport (SUS), Shanghai, China.

REFERENCES

1. Akuthota V, Ferreiro A, Moore T, Fredericson M. Core stability exercise principles. Curr Sports Med Rep 2008;7(1):39–44.
2. McGill S, (Editor). Low back disorders: evidence-based prevention and rehabilitation. UK: Human Kinetics; 2015.
3. Morris JM, Lucas DB, Bresler B. Role of the trunk instability of the spine. J Bone Joint Surg 1961;43(3):327–51.
4. Santos MS, Behm DG, Barbado D, DeSantana JM, Da Silva-Grigoletto ME. Core endurance relationships with athletic and functional performance in inactive people. Front Physiol 2019;10:1490.
5. Fogelholm M, Stigman S, Huisman T, Metsämuuronen J. Physical fitness in adolescents with normal weight and overweight. Scand J Med Sci Sports 2008;18(2):162–70.
6. Hamdani SMGH, He QZ, Hamdani UF, Hamdani MZH, Hamdani MDH. Comparison of cardiovascular endurance and speed between urban and rural female students. Int J Res Granthaalayah 2017;5(5):361–6.
7. Moraes AC, Pinto RS, Valamatos MJ, Valamatos MJ, Pezarat-Correia PL, Okano AH, *et al*. EMG activation of abdominal muscles in the crunch exercise performed with different external loads. Phys Ther Sport 2009;10(2):57–62.
8. Juan-Recio C, López-Plaza D, Barbado Murillo D, García-Vaquero MP, Vera-García FJ. Reliability assessment and correlation analysis of 3 protocols to measure trunk muscle strength and endurance. J Sports Sci 2018;36(4):357–64.
9. Fernandez-Fernandez J, Ulbricht A, Ferrauti A. Fitness testing of tennis players: How valuable is it?. Br J Sports Med 2014;48(Suppl 1):i22–31.
10. American College of Sports Medicine, (Editor). ACSM's health-related physical fitness assessment manual. Lippincott; 2013.
11. Strand SL, Hjelm J, Shoepe TC, Fajardo MA. Norms for an isometric muscle endurance test. J Hum Kinet 2014;40:93–102.
12. Anderson D, Barthelemy L, Gmach R, Posey B. Core strength testing: developing normative data for three clinical tests. 2013. Available from: https://sophia.stkate.edu/cgi/viewcontent.cgi?article=1031&context=dpt_papers
13. Warburton DE, Nicol CW, Bredin SS. Prescribing exercise as preventive therapy. CMAJ 2006;174(7):961–74.
14. Saporito G, Jernstedt G, Miller H. Test-Retest Reliability and Validity of the Plank Exercise. (2015). Linfield University Student Symposium: A Celebration of Scholarship and Creative Achievement. Event. Submission 17. [cited 5 January 2021] Available from: https://digitalcommons.linfield.edu/symposium/2015/all/17.
15. Suresh KP, Chandrashekara S. Sample size estimation and power analysis for clinical research studies. J Hum Reprod Sci 2012;5(1):7–13.
16. Hamdani SMZH, Zhuang J, Tian W, Hadier SG. Normative Reference Standard for Handgrip Strength among Adolescent Students in South Punjab Pakistan: A Cross-Sectional Study. J Bus Soc Rev Emerg Econ 2021;7(4):997–1009.
17. National Health and Nutrition Examination Survey-Anthropometry Procedures Manual [Internet]. 2007 [cited 5 January 2021]. Available from: https://www.cdc.gov/nchs/data/nhanes/nhanes_07_08/manual_an.pdf
18. Imai A, Kaneoka K. The relationship between trunk endurance plank tests and athletic performance tests in adolescent soccer players. Int J Sports Phys Ther 2016;11(5):718–24.
19. Patel R, Unisa S. Construction of national standards of growth curves of height and weight for children using cross-sectional data. Indian J Public Health 2014;58(2):92–9.
20. Cole TJ, Green PJ. Smoothing reference centile curves: the LMS method and penalized likelihood. Stat Med 1992;11(10):1305–19.
21. Ervin RB, Fryar CD, Wang CY, Miller IM, Ogden CL. Strength and body weight in US children and adolescents. Pediatrics 2014;134(3):e782–9.
22. Truter L, Pienaar AE, Du Toit D. Relationships between overweight, obesity and physical fitness of nine-to twelve-year-old South African children. South Afr Fam Practice 2010;52(3):227–33.
23. Lundgren SS, Nilsson JÅ, Ringsberg KA, Karlsson MK. Normative data for tests of neuromuscular performance and DXA-derived lean body mass and fat mass in pre-pubertal children. Acta Paediatr 2011;100(10):1359–67.
24. Beck CC, Lopes AD, Pitanga FJ. Anthropometric indicators as predictors of high blood pressure in adolescents. Arq Bras Cardiol 2011;96(2):126–33.
25. Lu Q, Wang R, Lou DH, Ma CM, Liu XL, Yin FZ. Mid-upper-arm circumference and arm-to-height ratio in evaluation of overweight and obesity in Han children. Pediatr Neonatol 2014;55(1):14–9.
26. Tokmakidis SP, Kasambalis A, Christodoulos AD. Fitness levels of Greek primary schoolchildren in relationship to overweight and obesity. Eur J Pediatr 2006;165(12):867–74.
27. Tanzil S, Jamali T. Obesity, an emerging epidemic in Pakistan-a review of evidence. J Ayub Med Coll Abbottabad 2016;28(3):597–600.
28. Deforche B, Lefevre J, De Bourdeaudhuij I, Hills AP, Duquet W, Bouckaert J. Physical fitness and physical activity in obese and nonobese Flemish youth. Obes Res 2003;11(3):434–41.
29. Steinberg LD, (Ed). Age of Opportunity: Lessons from the new science of adolescence. Houghton Mifflin Harcourt; 2014.
30. Ervin RB, Wang CY, Fryar CD, (Editors). Measures of muscular strength in US children and adolescents, 2012. NCHS data brief No. 139. US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics; 2013
31. Tomkinson GR, Carver KD, Atkinson F, Daniell ND, Lewis LK, Fitzgerald JS, *et al*. European normative values for physical fitness in children and adolescents aged 9–17 years: results from 2 779 165 Eurofit performances representing 30 countries. Br J Sports Med 2018;52(22):1445–56.

Address for Correspondence:

Syed Muhammad Zeeshan Haider Hamdani, Lecturer, Department of Sports Sciences, Bahauddin Zakariya University, Multan, Pakistan. **Cell:** +92-344-6449472
Email: syedhamdaniphd@gmail.com

Received: 5 Feb 2022 **Reviewed:** 1 Mar 2021 **Accepted:** 1 Mar 2021

Contribution of Authors:

SMZHH: Written, analysed and reviewed manuscript **JZ:** Supervised **SGH:** Reviewed **WT:** Proof reading
SDHH: Reviewed **SS:** Proof reading **SUF:** Data collection **SK:** Data collection

Conflict of Interest: There is no conflict of interest.
Funding Disclosure: There is no funding from any NGO for the study.