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Is Burpee Test Measure of Whole-Body Muscular Strength Endurance?

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Abstract

Introduction -The muscular strength endurance (MSE) is important physical trait that plays decisive role in sports performance. The Burpee Test specifically 3-minute Burpee Test (3MBT) has been extensively used to assess the muscular strength endurance in the past. For the best of our knowledge no attempt has been made to assess its validity by associating it with forearm plank (FP) (upper body) and vertical jump (VJ) (lower body) muscular strength assessment tools. The present study is an attempt in this direction.

Objective – To validate the ability of 3-minute Burpee test to measure the whole-body strength endurance by correlating it with FP and VJ. And assessing the predicative ability of forearm plank and vertical jump to predict the Burpee jump.

Material and Methods – 52 physically healthy university students (44 male and 8 female, mean age 19.62 years) who were engaged in sports training for last 3 months participated. They were tested on three tests successively for 3 days. 3MBT was correlated with FP and VJ.

Statistical Analysis – Pearson 'r' correlation and multiple regression were used to assess the degree and direction of association and predictive capacity of the variables.

Results – The results indicate strong, positive and significant correlation of 3MBT with FP and VJ. And high predictive ability of FP and VJ.

Key words: Burpee Jump, Forearm Plank, Vertical Jump, Muscular Strength Endurance.

Introduction

The fad for the development of muscular strength is as old as civilization. Earlier the muscular strength was developed and maintained largely for soldiers (Buckley & Hughes, 2008) and food gathering & survival. Indian traditional systems (Club swinging and Yoga) of exercising were centered on the enhancement of whole-body muscular strength. An English traveler Mountstuart Elphinstone (1815) mentioned in his travelogue that "the degree to which these exercises (club swinging) bring out the muscles and increase the strength is not to be believed …They are one of the best inventions which Europe could borrow from the East" (Heffernan, 2017).Yoga is known to improve muscular tone(Bala et al., 2017) and muscular fitness. The muscular strength endurance (MSE) is one of the important contributory physiological abilities for sport performance, motor

ability and physical fitness (Gomez-Bruton, et al., 2017). Physical fitness a product of muscular strength which provides base for the sports performance (Warburton, 2006) and higher functional ability. To the best of our knowledge no attempt has been made so far to validate its efficacy by correlating it with different and separate muscular strength assessment tools. In light of this the present study has been undertaken.

Muscular Strength (MS)

"It is the absolute amount of force that can be generated for one maximal voluntary contraction" (Buckley & Hughes, 2008). For optimal bodily performance and better control on posture, sufficient amount of core muscular strength is crucial (Chase et al., 2014). The muscular strength (power) positively correlates with bone strength (Gomez-Bruton et al., 2017) and overall physical fitness.

Muscular Endurance (ME)

ME is the dynamic physiological capacity of an individual to maintain the optimal contraction of muscular system for 30 seconds to 2 minutes. It has potential to beimproved with sustained practice of *Pranayama* and repetitive resistance training.

Muscular Strength Endurance (MSE)

The MSE is the joint expression of optimal effort and ability of a muscle to sustain that effort. Burpee, a synthesis of three physical exercises, was invented by American Physiologist Royal H. Burpee in 1930s for quicker assessment of physical fitness. The burpee style of exercise induces high level of fatigue in the upper part of human body (14.95% loss of power) (Bingley et al., 2019). Itis effective in sporting performance(Borysławski et al., 2020; Marian et al., 2019) and used for high intensity strength training(Cho et al., 2017;Evangelista et al., 2019).The 3-minute burpee test (3MBT)has been in use for estimation of whole-body muscular strength endurance.Podstawski et al.(2013, 2015, 2019)tested and attested the effectiveness of 3MBT on assessing muscular strength endurance on various age categories of men and women athletes.

Forearm Plank (FP)

Forearm is four touch points position(body touches ground) also known as abdominal bridge. FP has been used as fitness tool for abdominal toning, strength gaining (Badau et al., 2021), postural control (Chase et al., 2014) and testing the muscular strength of upper body (Tong et al., 2014).Practice of FP has been reported to significantly improves the MSE of upper body (Deep et al., 2020; Jernstedt et al., 2015; Kline et al., 2013; Ruivo et al., 2016). The balance and stabilization (Cortell-Tormo et al., 2017) during various physical functionalities of bipedal organisms is ensured by upper body MSE.FPis reported to activate the abdominal muscles (Byrne et al., 2014) especially rectus abdominis (Roth et al., 2016)which improvesthemuscularcorestrength and endurance. The FP has been used for assessment of the upper body muscular strength(Chase et al., 2014)body control. Tong et al. (2014, p 63) suggested that "the sport-specific endurance plank test is a valid, reliable and practical method for assessing global core muscle endurance in athletes." The reliability of FP was found to be 0.966 (Jernstedt et al., 2015) and 0.99 (Pojskic et al., 2020).

Vertical Jump

The vertical jump (VJ) (aka Jump and reach test, Standing Vertical Jump, Sargent Jump, Vertical Leap) is the joint efforts of glutealand quadricep muscular system. The well-articulated administration of VJ helps in assessing the strength, mobility and functional ability of lower body (leg muscles) (Buckthorpe et al., 2012; Quagliarella et al., 2011). Daugherty et al. (2021) reported that the lower Q-angle is significant predictor of VJ. The height gained through vertical jump

correlates positively and significantly with peak power output and jump height is the significant indicator of lower body muscular strength (Kons et al., 2017). Vastus medialis is responsible for lower body muscular strength and has the strongest correlation with jump performance (Xie et al., 2019).VJ was included for measuring lower body strength because of its high reliability and objectivity (0.93 and 0.93) (Aragon, 2000).

The aim of this study was to assess the ability of 3-minute burpee test (3MBT) to measure the whole-body muscular strength endurance by correlating it with valid and reliable upper and lower body strength measurement tests. The upper body strength was measured with forearm plank,a four-limb stiff platform pose also known as*ChaturangDandasan* in Yoga system (Fishman et al., 2019), while lower body strength was measured with vertical jump.

Materials and Methods

Sample: The selection of sample was based on the insight gained from the previous studies on MSE. The present study was undertaken to validate 3MBT with two separate external criteria was carried out on52volunteer athletes (44 male &8 female, mean age 19.62 years) who represented their university in Football and Handball. All participants were in active regular practice for minimum 3 monthsin their respective games. The participants who were on medication of any kind for the last 1 month or more were excluded. The written informed consent was obtainedfrom each participant prior to their inclusion.

Procedure & Measurement:

General

All three tests lasted for three consecutive days. Prior to each test the participants were asked to go for sufficient warm-up. The procedure to perform all the three exercises was demonstrated by the researcher and participants were allowed to practice for correctness of the exercise before the starting of final trial. On first day, one third participants (randomly selected) were tested on burpee test, one third on forearm plank and remaining one third on vertical jump. Same process was repeated on next two consecutive days.

Tools and Tests

3-minute Burpee Test

The test consists of four stages namely squat, throwing legs backward, withdrawing the legs to the previous position and standing with jump. This makes one complete cycle and termed as one burpee. The participants were categorically informed that if any one of the four stages is missed, that trial will not be counted in your score. The number of successfully completed burpees in 3 minutes formed the score.

ForearmPlank Test

The FP was performed with elevated position where body touches the ground at fourpoints i.e., elbow to forearm of both hands and toes of both legs. The head must be aligned with torso and legs and all three are to be kept in a straight line (Byrne et al., 2014). The participants were required to remain in this position for as much time as they can sustain. The participants were made aware that twice deviations from the stated position will be presumed that you have reached your maximum capacity and subsequently time will be stopped. The FP recordings were recorded to the nearest millisecond.

Vertical Jump Performance Test

The participants' dominant hand (all were right-handed) was wetted and dipped into white marking powder. They were asked to stand against the wall with their right side and extend their dominant hand to make a mark on the wall. From this position they were asked to jump and touch the wall as high as possible. The difference between these two points was their vertical jump score. Each participant was given three trials and the highest difference between these two marks was considered final score. The VJ recordings were recorded to the nearest millimeter.

Statistical Analysis

The raw data were tested for outliers using the Box plots.The detected outliers were treated with Welch's test for making decision to retain or discard the outlier. The Welch's test was conducted using the MS Excel '*t-test two sample assuming unequal variance*' function.If the difference between both the samples was significant at $p < 0.05$ the outliers were deleted else retained. However, in our case the difference between both samples was not significant ($t = 0.303$ df101), hence the outlier (only one) was retained. The descriptive statistics were calculated and presented in Table 1. The Pearson correlation coefficient and multiple regression wereused to figure out the correlation and predictive values among variables.

Table 1. Anthropometric and Functional Tests Descriptives of the Participants (n = 52)

Anthropometrics and Functional Test Measurements	Mean	SD	Range
Body Height (cm)	169.94	5.63	25.40
Body Mass (kg)	55.93	4.52	18.00
Age (yrs)	19.52	0.82	3.10
Forearm Plank (sec)	149.60	57.13	241
Vertical Jump (cm)	49.56	9.37	38
3MBT (no.)	80.88	18.160	86

Results

The correlation among the functional test variables presented in Table 2 are positive and statistically significant (atp <0.01).

Table 2.Correlation Among Functional Variables

Functional Variables	3MBT	Forearm Plank	Vertical Jump
3MBT	--	.670	.590
Forearm Plank		--	.648
Vertical Jump			--

Table 3. Model Summary

Model	R	R Square	Adjusted R Square	SE of the Estimate
1	.670[a]	.448	.437	13.621
2	.700[b]	.491	.470	13.224

The multiple linear regression (MLR) was calculated to predict the number of Burpee jumps in 3 minutes (BJ3M) based on the forearm plank holding capacity and distance covered in vertical jump. MLR yielded a significant equation (F1, 2) = 40.657, 23.592 at p < .01, with an R^2 of 0.491 (Table 3). The forearm plank and vertical jump together account for 49.1% of variance in BJ3M. The number of BJ3M increased 32.23 for each secondholding of plank and increase in each centimeter of vertical jump together.Both forearm plank and vertical jump were significant predictors of BJ3M.Taken separately the forearm plank is significant predictor of BJ3M (F 1) = 40.657 at p <.01 accounting for 44.8% of variance (R^2 = 0.448).The scatter plot of regression standardized predicted values that are plotted against the number of Burpee jumps in 3 minutesare presented in Fig 1.

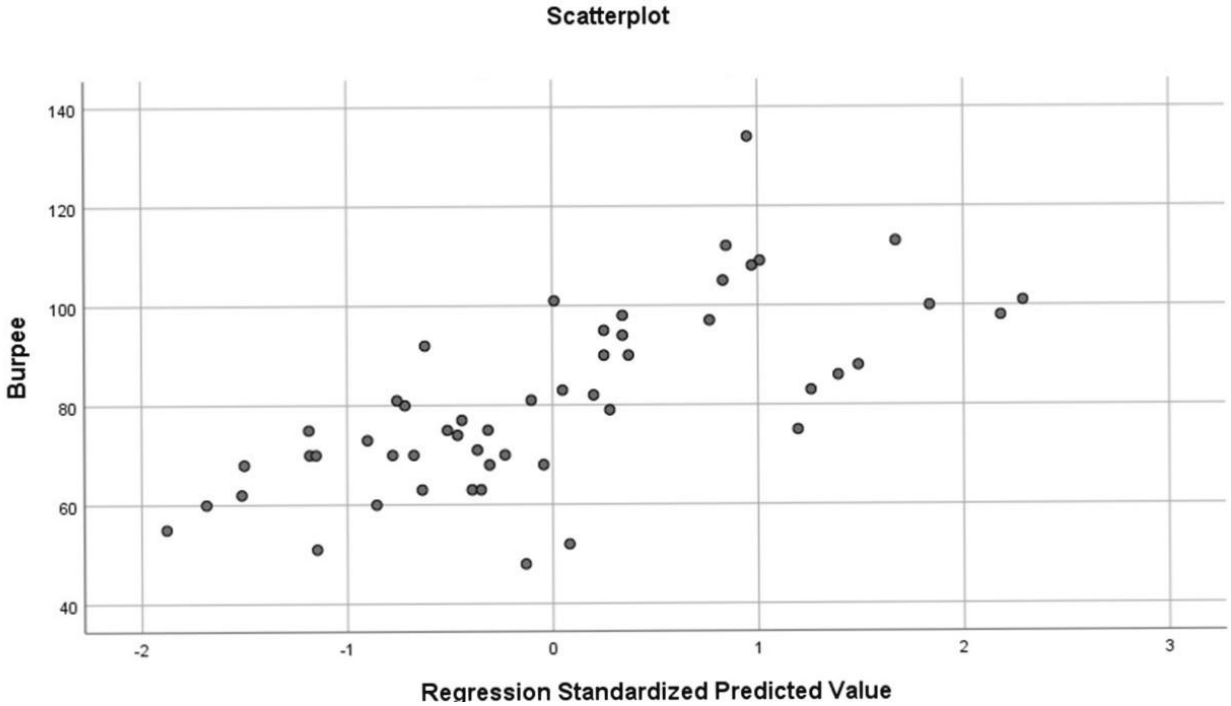

Figure 1: Scatter Plot of Regression Standardized Predicted Values

Discussion

The study was intended to validate 3MBT as the whole-body muscular strength endurance assessment tool by correlating it with forearm plank and vertical jump. The present study is to validate the 3MBT as tool of measuring whole body muscular strength endurance. The selected variables (Burpee test, Forearm plank and Vertical jump) have strong, positive and significant correlation among themselves.The findings validated the ability of 3MBT to measure the whole-body MSE. The strong correlation with forearm plank and vertical jump is indicative of the ability of 3MBT to measure the MSE. The high predictive value of forearm plank explains that FP strongly correlates with 3MBT, the findings are in consonance with (Tong et al., 2014) where they found that plank test is a "valid, reliable and practical method for assessing global core muscle endurance in athletes". The height gained through VJ is significant indicator of muscular strength(Kons et al., 2017). The strong correlation and predictive ability of VJ of 3MBTfound in the present study are indicative of significant relationship. Similarly, the findings of the present study are in consonance with thefindings of Xie et al. (2019) which reports that the lower body muscular strength has the strongest correlation with jump performance.

Conclusions

The 52 university level students were enrolled for studying and validating the ability of 3MBT as a measure of whole-body MSE. The participants were administered with 3MBT after warm up followed by forearm plank and vertical jump in three successive days. The Pearson 'r' correlation was computed to measure the degree and direction of association between Burpee jump, forearm plank and vertical jump. Multiple regression was computed to measure the predictive power of forearm plank and vertical jump to predict the ability of BJ3M. The results indicated that forearm plank and vertical jump significantly strongly and positively correlates with BJ3M. Hence, based on the findings of this study it can be inferred the 3MBT is a valid tool to measure the whole-body muscular strength endurance.

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Conflict of Interest

Authors declare no potential conflict of interest of any kind.

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