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Correlation of Cardiorespiratory Fitness and Perceived Fatigue among Young DPT Students: A Cross-Sectional Study

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A B S T R A C T

Background: Cardiorespiratory fitness is a measure of how well oxygen is transported to the body during exertion and perceived fitness is the measure of perceived exhaustion and tiredness.

Objective: To determine the correlation between cardiorespiratory fitness and perceived fatigue among young DPT adults.

Methodology: The methodology was approved by the Ethical Review Committee of Foundation University Islamabad. The study design was cross-sectional correlation analytical. The data was collected from undergraduate students of Foundation University Institute of Rehabilitation Sciences, Islamabad. The sampling technique was non-probability consecutive sampling. The sample size was 218. Data of 176 participants was collected due to limitation of time. Informed consent was taken. Participants were selected through inclusion and exclusion criteria and screened out using Physical Activity Readiness-Questionnaire. They were asked to fill the Situational Fatigue Scale and then perform the Single Stage Sub Maximal Treadmill Walking Test/Ebbeling Treadmill Test. During the test, participant's level of exertion and fatigue was measured using Borg Rating of Perceived Exertion. Then VO2 max and Situational Fatigue Score were calculated.

Results: There was weak positive correlation between cardiorespiratory fitness and perceived fatigue which was statistically insignificant (p value 0.545 and spearman's rho 0.046).

Conclusion: Cardiorespiratory fitness varies among young DPT students and is not related to their perceived fatigue.

Keywords: Cardiorespiratory fitness, Perceived fatigue, Physical exertion

Introduction

The concept of fitness is far older than the extent to which we can look at time. History is brimmed with the references of fitness focusing on the necessity of maintaining a healthy body for a healthy mind. With the increasing technology and the luxuries this new man has developed, the spectrum of physical fitness has shifted from this so-called "Healthy body for a healthy mind" to "Lazy body and artificial intelligence". Chiefly, the automation in industries and modifications in the transportation industry served the basis for this substantial decline in physical activity levels of human race. The current circumstances had led to the adaptation of a more sedentary lifestyle. These all had resulted in a steady and significant deterioration in the level of physical activity as well as cardiorespiratory fitness. The modern generation has the lowest levels of physical excursion patterns as compared to history and is further declining. Cardiorespiratory system is the means through which the oxygen is transported to the body during exertional activities[1] while cardiorespiratory fitness is the measure of how well the oxygen is transported to the body systems. The gold standard method for measuring CRF is measuring the aerobic capacity (VO_2 max).[2] Aerobic capacity is easy to perform as well as to measure and is a direct measure of CRF.[2]The preliminary model explaining the maximal oxygen uptake was presented back in 1923 where this concept was demonstrated practically by Hill and Lupiton. There is a gradual increase in the oxygen uptake as the activity is increased till the body systems reach the peak of oxygen uptake. Beyond this level, there is no further increase in the oxygen uptake, instead, a constant increase in the oxygen uptake is observed. The plateau was formed demonstrating the results that no further oxygen is taken up even after increasing the exercise intensity, by the respiratory, cardiac and vascular structures as they reach their physiological limitation. Thus this concept of maximal oxygen consumption (VO_2 max.) was established.[3] Cardiorespiratory fitness (CRF) is one of the basic and primary indicator of physical fitness.[1] It is proficient at describing the overall fitness of human body.[1]

Cardiorespiratory fitness is one of the primary and independent indicators of the physical fitness.[1] High level of cardiorespiratory fitness is associated with low levels of cardiovascular diseases and it indicates significantly low mortality rates involving cardiac or vascular events.[4] In order to attain an ideal cardiovascular health status, AHA has devised impact goals.[6] The substantial value of cardiorespiratory fitness as a preliminary independent health indicator in hospitals and the independent settings cannot be overlooked. However, no national or international guidelines have been established, to use cardiorespiratory fitness as a basic risk assessment tool.[5]

Numerous tests are available for the measurement of VO_2max using treadmill and cyclic ergometers. A walking/running distance should be a minimum of one mile to test the efficiency of one's cardiorespiratory system.[4] The VO_2max is measured using the direct method (by measuring the respiratory gases) or by using the indirect method (by using standardized equations for the estimation of aerobic capacity). Tests for measuring the aerobic capacity are divided in two broad categories; maximal exercise tests and submaximal exercise tests.

Maximal exercise tests for the measurement of VO_2max involve the maximal physical excursion of the participant involved. These are the graded exercise stress tests till the level of exhaustion. These types of tests are called performance tests.[7] This involves the excursion to 100 percent that is a full excursion of involved participant. Both cyclic ergometers as well as treadmills are suitable for maximal exercise tests. However, the use of treadmill produces best results. Precautions must be taken while performing these tests as exhaustion to a maximal level might provoke an underlying medical condition. So, these tests require constant supervision of experienced medical staff to avoid any mishaps in the lab. Examples of maximal exercise tests include Bruce maximal exercise test, Balke maximal exercise test, Astrand maximal cycle test and Storer-Davis maximal exercise test.[8] When the limits of participant's aerobic capacity are tested by exhausting the participant before the maximal physiological limit is reached, such tests are termed as submaximal exercise tests. The heart rate of the participant is kept within the range of 70%-80% of the maximal predicted heart rate. The results are then extrapolated to measure the VO_2max.These tests predict the value of VO_2max precisely, and hence, are also termed as predictive exercise test.[9] These tests are safe, less expensive and these are easy to conduct. Examples of submaximal tests include the modified Canadian aerobic fitness test, YMCA 3 minute step test, treadmill submaximal exercise test and cycle ergometer submaximal exercise test.[10]

In terms of safety, walking is more suitable than running and common population is more accustomed to walking than to jog or paddle. While using the cycle tests, VO_2max is 5-25% lower as compared to the treadmill tests.[11] These tests are avoided in case when the participant has balance or visual disturbances, any diagnosed foot neuropathy or any orthopedic or musculoskeletal dysfunction that would be aggravated by walking.[12]

Ebbeling treadmill test is standard single staged submaximal treadmill test that predicts maximum oxygen uptake precisely and is commonly used in clinical settings.

Fatigue is defined as a debilitating symptom which hinders the cognitive as well as physical performance by mending the perceived fatigability and performance fatigability. Performance fatigue (also known as physiological fatigue) predominantly limits the abilities of muscles to generate force. Performance fatigue is measured usually by measuring the active muscular contraction force.[13]

Perceived fatigue however, is the constant feeling of exhaustion and weakness.[13] The perception of fatigue varies among individuals depending upon the presence of other factors like sleep turbulence and the presence of any central or peripheral neurological dysfunction.[14] High levels of perceived fatigue in the absence of diagnosed depression or anxiety is suggestive of behavioral and mood related disorders.[15] Perceived fatigue can be measured while performing any physical activity or at rest. Perceived fatigue is being measured on the basis of the impediments it causes and most of them are related to the assessment of patients with any fatigue-linked medical condition.[16] Little work is done on the development of a fatigue related tool that measures fatigue levels that does not substantially affect activities of daily living or a tool that measures fatigue levels in otherwise normal population.

Situation fatigue scale is distinctive in a way that it covers both domains of fatigue; mental as well as physical with the focus on the activities of daily living.[17] Situation fatigue scale is a valid tool in the assessment of self-narrated fatigue intensity. Situation fatigue scale is a 13-question rating scale with a rating score range of 0-5.[17] Also, 5 of these questions are related to mental fatigue and 8 of these questions are related to the physical dimension of fatigue.

Methodology

A cross-sectional correlation analytical study was conducted among 176 healthy young adults. Healthy adults from Foundation University School of Health Sciences, Islamabad were included using non-probability consecutive sampling.

The sample size of 218 was calculated using Raosoft sample size calculator. Population size was kept at 500 with a margin of error 5%, confidence interval 95% and response distribution 50%. Data of 176 participants was collected due to limitation of time.

The ethical approval was taken from Foundation University School of Health Sciences ethical approval board (FF/FUMC/215-336 Phy/23). Healthy young adults from undergraduate program of DPT within the age group of 18-25 years, of both male and female genders, and BMI 18-25 kg/m2 were included. Participants were screened out using Physical Activity Readiness Questionnaire (PAR-Q) and any participant having a history or a current diagnosis of cardiovascular, respiratory, neurological, and musculoskeletal pathologies were excluded from the study.

The Single Stage Submaximal Treadmill Walking Test or Ebbeling Treadmill Test, an eight-minute walking submaximal test, was used to measure one's aerobic capacity/VO_2 max. It is suitable for non-athletic adults as it is easy to perform and does not require medical supervision.[18] It has good validity and reliability (r=0.96).[18]

The Situational Fatigue Scale was used to evaluate physical and mental fatigue, through 13 questions regarding routine activities. It has a scale from 0-5 and a total score of 65.[17] It has a reliability of 0.6. High score shows increased level of fatigue.[17]

Borg Rating of Perceived Exertion (RPE) was used to evaluate fatigue, breathlessness and level of exertion during any activity.[19] It is a valid and reliable tool with ICC 0.78.[20] The participants with a score greater than 14 were excluded.

Physical Activity Readiness-Questionnaire (PAR-Q) was used to screen out the participants having a history or a current diagnosis of cardiovascular, respiratory, neurological or musculoskeletal pathology.[21] It is a valid and reliable tool with ICC 0.895.[21]

Pulse Oximeter was used to measure heart rate and oxygen saturation. It has a reliability of 0.93.[22] Heart rate was kept within 70% of maximal heart rate of participant.

Participants were selected based on inclusion and exclusion criteria. An informed consent was taken from all the participants. Demographic data was collected on self-structured questionnaire.

Then Situational Fatigue Scale was filled by participants, and their blood pressure was measured. Participant's predicted maximal heart rate (PMHR) was calculated by using the equation PMHR=208-(0.7xage).[23] and then 50% and 70% of PMHR was calculated. The pulse oximeter was attached, and participants were asked to walk on treadmill. The test started at slow speed to make the participant comfortable and to warm up. In the first 4 minutes, the grade was kept at 0% and speed was kept at a range that brought heart rate between 50% and 70% of PMHR (speed: 2-4.5 mph i.e., 3.2-7.2 kmph). After 4 minutes, the speed was kept constant, and grade was increased to 5%. Heart rate was measured after every minute. After 8 minutes, grade was decreased to 0% and speed was gradually decreased to allow the participant to cool down. During the test, the participant was asked about how he/she was feeling and their level of exertion was assessed using Borg rating of perceived exertion (rpe). Blood pressure was measured again after completion of field test. Then the heart rate, speed and gender were used in the following equation to predict the VO2 max.

VO2 max = 15.1 + 21.8 (speed in mph) - 0.327 (heart rate) - 0.263 (speed x age) + 0.00504 (heart rate x age) + 5.98 (gender: male= 1, female= 0)

Data was analyzed using SPSS version 21. Normality of data was checked using Kolmogorov Smirnov test as the sample size was greater than 50. As p-value was less than 0.05, Spearman's correlation test was applied to find the correlation.

Results

All participants were unmarried with predominantly females (89.77%). Mean age in years of males (n=18) was 21.5±2.3 while mean age of females (n=158) was 20.7±1.7. Mean of Body Mass Index in males was 21.6±2.1 while in females was 21.3±2.3. (Table 1)

Spearman's rank order test was applied, as data was non-normally distributed to find out correlation between VO2 maximum measured through Ebbeling test and perceived fatigue measured on fatigue scale score. The normality testing showed VO2 max p-value of 0.010 and p-value for Perceived Fatigue Score is 0.019. Results of Spearman's rank order test indicated that there was no statistically significant correlation between VO2 maximum and perceived fatigue (rs=0.046, p=0.545). (Table 2)

Analyzing the data of VO2 max showed that majority of the participants were in the "Very poor range" as per normative value of VO2 max.[24] Among females 33.5% were in "very poor" while 8% fall into "good", "excellent" and "superior" group range each. None of the male participant fall into "poor" range, moreover, 33.3% fall into "superior" group range. (Figure 1)

More the value on Fatigue scale score more will be the perception of fatigue.[17] The results showed mean value of perceived fatigue for males was 22.1±6.9 while for females was 18.9±10.5.(Table 3)

Table No. 1 shows demographic data of the participants

Gender	%(n)	Age (Years) Mean±SD	BMI (ml/kg/min) Mean±SD
Male	10.3(18)	21.5±2.3	21.6±2.1
Female	89.7(158)	20.7±1.7	21.3±2.3
SD = Standard Deviation			

Table No. 2 shows Spearman's rank order test results

Spearman's rank order test		
Variables	Correlation co-efficient - Rs	p-value
VO2 max (ml/kg/min)	0.046	0.545*
Fatigue perception		
**p>0.05means no statistically significant correlation between the variables*		

Table No. 3 Mean and standard deviation of fatigue scale score

Gender	%(n)	Fatigue scale score Mean±SD
Male	10.3(18)	22.1±6.9
Female	89.7(158)	18.9±10.5
SD = Standard Deviation		

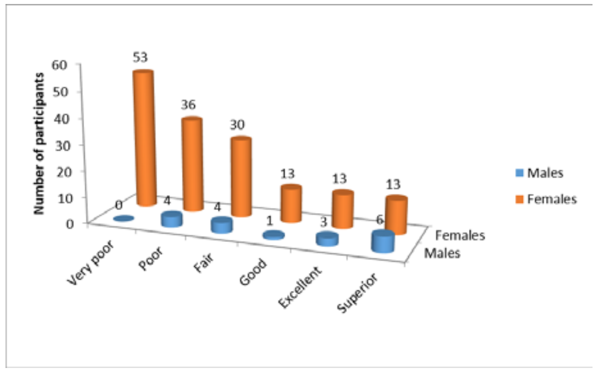

Figure 1 shows number of participants in each category of VO2 maximum

Discussion

This study was designed to identify the correlation between cardiorespiratory fitness and perceived fatigue among healthy young individuals. The results of this study support the notion that no significant correlation exists between cardiorespiratory fitness and perceived fatigue levels of an individual.

In a study conducted by Stijen Ventighem, healthy young adults having moderate to high levels of body fat and composition show a negative association between perceived fatigue and high levels of physical performance.[25] Moreover, her study concluded that physical activity levels of an individual are not related to body fat.[25] However, the current study states that fitness is not related to fatigue perception. Also, participants with low body fat were selected by keeping the BMI within range 18-25kg/m^2.

Valet Maxime stated that perception of fatigue is weakly associated with fitness, measured using aerobic capacity, mobility and depression.[26] The study population that was used in his study was patients with Multiple Sclerosis in contrast to healthy adults in the current study.[26]

The possible explanation to these results that no correlation exists between CRF and perceived fatigue levels is the fact that the cardiorespiratory fitness of an individual is dependent on most factors rather than just fatigue perception. The CRF is shaped by unending interactions between genetic as well as environmental factors. In 2023, M. Behrens investigated that high levels of performance fatigue demonstrate increased performance decrements.[16] But it does not signify the role of perception on performance.

A large variety of tools for the measurement of fatigue is available and no scale can be recognized as "Gold Standard".[27] However, the different scales for the measurement of fatigue are reliable for measuring different dimensions of fatigue.[28]

Based on this theory, situation fatigue scale is a multidimensional instrument covering the perceived fatigue based on physical and mental dimension.[17] So the perceived fatigue levels are more accurately explored by using situation fatigue scale as compared to other fatigue scales like Dutch exertion fatigue scale, fatigue assessment instrument, mental fatigue subscale and physical fatigue subscale. Hence use of situation fatigue scale was a wise choice for fatigue measurement due to the reason that it has outshined the other traditional fatigue scales. Also, that the conventional fatigue scales are predominantly designed for diseased population keeping in mind the specific limitations of specific diseases.[29] but in terms of normal population, situation fatigue scale is a better option.[17]

The common practice is that fatigue questionnaires are usually filled by comprehending fatigue as a feeling of tiredness, but the literature suggests fatigue is a feeling of tiredness, sleepiness, lack of motivation, physical discomfort and lack of energy.[30] So, it is difficult to calculate the exact levels of perceived fatigue among individuals covering all the dimensions and categories of perceived fatigue. Further studies need to be directed in this path to completely comprehend perceived fatigue.

Body mass index is also related to fatigue levels. Explaining it in terms of gender, body mass of women is positively associated with fatigue levels with the women having high body mass have high fatigue levels as well.[31] However, in case of men, body mass is not linked with fatigue levels.[31] This significantly supports the results of this study, in which the sample was not equally distributed in terms of gender as it was not a gender related study primarily. The distribution was 10.33% males and 89.77% females. Confounding factors of BMI was managed as all selected participants were in normal range of BMI. These results were consistent with a study conducted by Leonard A. Kaminsky and his colleagues in 2015 in which he described in detail that there is an overall mean 27% difference in VO_2max of males and females.[32] A thorough study can be conducted on the establishment of association between body mass and fatigue levels considering the gender difference. As the population of FUIRS is not equally distributed in terms of gender, VO_2max values would be different when a gender distribution study is conducted.

Limitations and Recommendations: Fatigue is highly associated with the psychological stresses like anxiety, emotional problems and depression, irrespective of the gender.[14] If we link this concept to our study and think rationally, as most of the data was collected during the start of the semester after a long summer vacation, it is suggested that the absence of stressors like exams and assignments might have influenced the fatigue levels of students. It is possible that students respond in a different way to fatigue, when assessed during or near to exam season. Thus, further studies can be conducted to identify the interesting facts about the changes in fatigue levels and perception by the students during exam season. A comparison study on fatigue levels can also be conducted, figuring out the difference in fatigue perceptions by students before, during and after the exam season. Some significant limitations included fear of the treadmill as some participants were not accustomed to walking on the treadmill. Pulse oximeter required regular cleaning due to hand sweating.

Conclusion

Perceived fatigue is not dependent on cardiorespiratory fitness as no correlation was found. The perception of tiredness varies from individual to individual despite their cardiorespiratory fitness level. Cardiorespiratory fitness of an individual depends on multiple genetic and environmental factors due to which no statistically significant correlation was found in the variables.

Conflict of Interest: None

Funding Sources: None

Data Availability Statement: The datasets generated and/or analysed during the current study are not publicly available due to ethical, legal, and participant confidentiality considerations but may be available from the corresponding author upon reasonable request, subject to institutional approval where applicable.

Disclaimer: This was part of thesis project of DPT program of Foundation University College of Physical Therapy, Foundation University Islamabad. We as authors want to declare that we used AI-assistant tools in this article for improving language. We authors are fully responsible for the accuracy, originality, integrity, and scientific validity of this article.

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