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Research Article

ASSOCIATION BETWEEN CARDIORESPIRATORY ENDURANCE AND PHYSICAL ACTIVITY LEVEL AMONG OVERWEIGHT INDIVIDUALS

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Abstract

Background: Physical inactivity is a major risk factor for cardiovascular disease and metabolic disorders in overweight individuals. Understanding the relationship between cardiorespiratory fitness and physical activity levels is crucial for developing effective interventional strategies. **Objective:** To examine the correlation between cardiac endurance and physical activity levels in overweight individuals using objective and subjective assessment methods. **Methods:** This cross-sectional correlation study included 100 overweight individuals (BMI 23-27.5 kg/m²) aged 18-40 years recruited. Cardiorespiratory endurance was assessed using the Queen's College Step Test (QCST) to estimate VO_2 max. Physical activity levels were evaluated using pedometer-measured step counts over 24 hours and Global Physical Activity Questionnaire (GPAQ) measures. Participants were categorised into low, moderate, and high fitness/activity levels. Statistical analysis included associations were examined using likelihood ratio tests. **Results:** The participants mean age and BMI was 21.39±1.86 years and 25.47±1.17 kg/m² respectively. For cardiorespiratory endurance, 44% demonstrated moderate fitness, 42% low fitness, and 14% high fitness. Pedometer assessment showed 71% were moderately active, 26% physically active, and 3% inactive. GPAQ assessment revealed 94% were moderately active and 6% had low activity. Significant positive correlations were found between cardiorespiratory endurance and both pedometer-based physical activity ($p=0.003$) and GPAQ-based physical activity ($p=0.004$). Among participants with high cardiac endurance, 71.42% were physically active by pedometer assessment. **Conclusion:** Significant positive correlations exist between cardiorespiratory endurance and physical activity levels in overweight individuals. Both objective and subjective physical activity assessment methods demonstrated associations with cardiac endurance, supporting their utility for fitness evaluation and intervention planning in this population.

Keywords: Body mass index; Cardiorespiratory fitness; Global Physical Activity Questionnaire; Pedometer; Physical activity; VO_2 max.

INTRODUCTION

Overweight and obesity have reached epidemic proportions globally, with more than 1 billion adults affected worldwide [1]. Between 1980 and 2013, the prevalence of overweight increased from 27.5% to 47.1% among adults, with the number of affected individuals rising from 857 million to 2.1 billion.(2) This dramatic increase has profound implications for public health, as excess body weight is associated with numerous chronic conditions including cardiovascular disease, type 2 diabetes, certain cancers, and musculoskeletal disorders [3,4]. The World Health Organization (WHO) has established specific body mass index (BMI) cut-off points for Asian populations, recognising that Asians generally have higher body fat percentages than Caucasians at the same BMI [5,6]. For Asian populations, the WHO defines overweight as BMI 23-27.5 kg/m² and obesity as BMI ≥27.5 kg/m², lower than the standard international cut-offs [7]. Physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure and encompasses occupational, recreational, household, and transportation activities [8]. Regular physical activity is associated with numerous health benefits, including reduced risk of cardiovascular disease, type 2 diabetes, certain cancers, and improved mental health and quality of life [9,10]. Conversely, physical inactivity has been identified as a major risk factor for chronic diseases, contributing to hypertension, obesity, ischemic heart disease, stroke, and musculoskeletal disorders [11,12].

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The relationship between physical activity and being overweight is complex and bidirectional. Excess body weight may limit physical activity capacity, while physical inactivity contributes to weight gain and associated health complications [13]. Overweight individuals often demonstrate compromised cardiorespiratory fitness, which is both a consequence of excess adiposity and a predictor of cardiovascular morbidity and mortality independent of BMI [14,15]. Cardiorespiratory endurance, commonly quantified as maximal oxygen uptake (VO_2max), reflects the integrated capacity of the cardiovascular and respiratory systems to deliver oxygen to active skeletal muscles during sustained physical activity [16]. VO_2max is widely regarded as the gold standard indicator of aerobic fitness and a strong predictor of cardiovascular health and all-cause mortality [17,18]. Evidence consistently demonstrates that VO_2max is significantly reduced in overweight and obese individuals compared with their normal-weight counterparts [19,20].

Assessment of physical activity and cardiorespiratory fitness

Accurate assessment of physical activity levels is essential for epidemiological research, clinical practice, and intervention design. Both objective and subjective methods are available, each with distinct advantages and limitations [21,22].

Objective Assessment - Pedometers: Pedometers are simple, inexpensive body-worn motion sensors that count steps by detecting movement of the person's body [23]. They provide objective quantification of ambulatory activity and have demonstrated acceptable validity and reliability for measuring walking in various populations [24,25]. Pedometer-based physical activity can be categorised as: inactive (<5,000 steps/day), moderately active (5,000-9,999 steps/day), and physically active (≥10,000 steps/day) [26,27].

Subjective Assessment - Questionnaires: The Global Physical Activity Questionnaire (GPAQ) was developed by WHO in 2002 as part of the stepwise approach to chronic disease surveillance [28]. The GPAQ comprises questions capturing physical activity in three behavioral domains: work, transportation, and recreation [29]. It has demonstrated acceptable reliability and validity across diverse populations and cultural contexts [30].

Cardiorespiratory Fitness Assessment: The Queen's College Step Test (QCST) is a validated submaximal fitness test that estimates VO_2max based on post-exercise heart rate recovery [31]. It offers a practical alternative to direct laboratory VO_2max measurement, which requires expensive equipment and trained personnel [32]. The QCST has shown good validity and reliability in various populations and is particularly suitable for large-scale assessments [33,34].

Rationale and Research Gaps

While laboratory-based cardiopulmonary exercise testing remains the gold standard for fitness assessment, it is time-consuming, expensive, and impractical for population-level screening [35]. Field-based assessments using pedometers, questionnaires, and submaximal exercise tests offer feasible alternatives for community and occupational health settings.
Previous studies have examined relationships between physical activity and cardiorespiratory fitness with mixed findings [36,37]. Discrepancies may arise from methodological differences, population characteristics, and variations in assessment tools. Few studies have simultaneously employed both objective and subjective physical activity measures to examine their correlations with cardiorespiratory fitness specifically in overweight Asian adults. Understanding the relationship between cardiorespiratory endurance and physical activity levels in overweight individuals is crucial for several reasons. First, it may inform the development of targeted interventions to improve both fitness and activity levels. Second, it can guide clinical decision-making regarding appropriate assessment tools. Third, establishing these relationships in Asian populations is important given their unique body composition characteristics and increasing prevalence of overweight. Therefore, this study aimed to examine the correlation between cardiorespiratory endurance (assessed via QCST) and physical activity levels (assessed via both pedometer and GPAQ) among overweight individuals in an urban Indian population.

METHODS

Study Design and Setting

This cross-sectional correlational study was conducted in an urban setting. Participants were recruited from various office workplaces. Ethical approval was obtained from an institutional human ethics committee, and written informed consent were secured from all participants.

Participants

Sample Size: Based on previous literature and feasibility considerations, a sample size of 100 participants were determined adequate for correlation analysis.

Sampling Method: Convenient sampling was employed based on inclusion and exclusion criteria.

Inclusion Criteria:

- Age 18-40 years
- Both males and females
- BMI 23-29 kg/m² (overweight category for Asian populations) [5].
- Waist circumference >76 cm for men and >65 cm for women
- Office workers (sedentary occupation)
- Willing to participate with informed consent

Exclusion Criteria:

- Known cardiovascular, metabolic, respiratory, orthopedic, or neurological conditions
- Current use of medications affecting heart rate or exercise capacity
- Pregnancy
- Recent surgery or injury limiting physical activity
- Inability to perform step test due to any reason

Procedures

The study protocol was completed over three consecutive days:

Day 1: Participants completed demographic information and the GPAQ. Height (measured to nearest 0.1 cm using standard measuring tape), weight (measured to nearest 0.1 kg using calibrated digital scale), and waist circumference were measured. BMI was calculated as weight (kg) divided by height in meter squared (m²). Participants received instructions for the QCST and were advised to avoid caffeine and strenuous activity before testing.

Day 2: The QCST was performed between 9:00-11:00 a.m. Following completion, participants were provided with pedometers (Omron brand) and instructed on proper wear and use.

Day 3: Participants wore pedometers for one complete day (from waking to sleeping). They were instructed to photograph pedometer readings before bed and return devices the following morning.

Outcome Measures

Cardiorespiratory Endurance - Queen's College Step Test
The QCST protocol was conducted as follows:

Equipment:

- Step platform: 41.3 cm (16.25 inches) height
- Metronome set at: 88 beats/min (22 steps/min) for females; 96 beats/min (24 steps/min) for males

- Heart rate monitor
- Stopwatch

Protocol:

- Resting heart rate was recorded
- Target heart rate (85% of age-predicted maximum) was calculated: 85% × (220 - age)
- Participants stepped up and down continuously for 3 minutes, maintaining metronome cadence
- Stepping pattern: up-up-down-down, with either foot able to lead
- Heart rate was monitored continuously
- At 3 minutes, stepping ceased immediately
- After 20 seconds of recovery, 15-second pulse count was obtained
- This count was multiplied by 4 to obtain recovery heart rate (beats/min)

VO_2max Estimation:

- Males: VO_2max (ml/kg/min) = 111.33 - (0.42 × recovery HR)
- Females: VO_2max (ml/kg/min) = 65.81 - (0.1847 × recovery HR)

Classification of Cardiorespiratory Fitness:(31,38)

- High: Males >51.2 ml/kg/min; Females >42.6 ml/kg/min
- Moderate: Males 46.8-51.1 ml/kg/min; Females 36.7-42.5 ml/kg/min
- Low: Males <46.8 ml/kg/min; Females <36.7 ml/kg/min

Test Termination Criteria:

- Achievement of 85% age-predicted maximum heart rate
- Participant request to stop
- Signs of excessive fatigue or discomfort
- Inability to maintain proper stepping cadence

Physical Activity Level – Pedometer

Participants wore pedometers positioned on the waistband at the mid-thigh level for one complete day. They recorded the total step count before sleeping. Classification was based on Tudor-Locke and Bassett criteria [27]

- Inactive: <5,000 steps/day
- Moderately active: 5,000-9,999 steps/day
- Physically active: ≥10,000 steps/day

Physical Activity Level – GPAQ

The GPAQ consists of 16 questions assessing physical activity across three domains: [28,29]

- Work-related physical activity (vigorous and moderate)
- Travel to and from places (walking or cycling)
- Recreational physical activity (vigorous and moderate)

Physical activity intensity is expressed in metabolic equivalents (METs), with vigorous activity assigned 8 METs and moderate activity assigned 4 METs. Total physical activity in MET-minutes per week was calculated by summing up the products of time spent in each activity category multiplied by its MET value.

Classification of Physical Activity (MET-min/week) : [30]

- Low: <600 MET-min/week
- Moderate: 600-3,000 MET-min/week
- High: >3,000 MET-min/week

For this study, MET-minutes were converted to activity counts for categorical analysis:

- Low: 101-1,951 counts/min
- Moderate: 1,952-5,724 counts/min
- High: ≥5,725 counts/min

Statistical Analysis

Data was analysed using SPSS. Descriptive statistics included frequencies and percentages for categorical variables and means with standard deviations for continuous variables. The likelihood ratio test was used to examine associations between cardiorespiratory endurance categories and physical activity level categories. Statistical significance was set at $p<0.05$.

RESULTS

Participant Characteristics

A total of 100 overweight individuals (BMI 23-29 kg/m²) completed all study procedures. Participant characteristics are presented in Table 1.

Table 1. Baseline characteristics of study participants (n=100)

Variable	Mean ± SD	Range
Age (years)	21.39 ± 1.86	18-26
Height (cm)	160.36 ± 8.72	144-188
Weight (kg)	65.74 ± 8.43	48.6-87.4
BMI (kg/m²)	25.47 ± 1.17	21.9-28.9
Waist circumference (cm)	81.24 ± 6.35	68-96

SD: Standard deviation; BMI: Body mass index

The mean age was 21.39 years, indicating a predominantly young adult population. All participants met the WHO criteria for overweight in Asian populations (BMI 23-27.5 kg/m²), with a small proportion in the obese range.

Distribution of cardiorespiratory fitness levels

Table 2 presents the distribution of participants across cardiorespiratory fitness categories based on estimated VO_2max values.

Table 2. Distribution of cardiorespiratory fitness levels based on VO_2max (n=100)

Fitness Level	Frequency	Percentage (%)
High	14	14.0
Moderate	44	44.0
Low	42	42.0
Total	100	100.0

The majority of participants (44%) demonstrated moderate cardiorespiratory fitness, while 42% showed low fitness levels. Only 14% achieved high fitness classification. This distribution indicates that 86% of overweight participants had suboptimal cardiorespiratory fitness.

Distribution of physical activity levels

Physical activity levels assessed by both objective (pedometer) and subjective (GPAQ) methods are shown in Tables 3 and 4.

Table 3. Distribution of physical activity levels based on pedometer assessment (n=100)

Activity Level	Frequency	Percentage (%)
Physically Inactive (<5,000 steps/day)	3	3.0
Moderately Active (5,000-9,999 steps/day)	71	71.0
Physically Active (≥10,000 steps/day)	26	26.0
Total	100	100.0

Table 4. Distribution of physical activity levels based on GPAQ assessment (n=100)

Activity Level	Frequency	Percentage (%)
Low Active	6	6.0
Moderately Active	94	94.0
Highly Active	0	0.0
Total	100	100.0

Pedometer assessment revealed that the majority (71%) of participants were moderately active, with 26% achieving recommended daily step counts (≥10,000 steps). Only 3% were classified as inactive. In contrast, GPAQ assessment classified 94% as moderately active and 6% as low active, with no participants in the highly active category. This discrepancy between methods suggests potential overestimation by self-report measures.

Association between cardiorespiratory endurance and physical activity

Tables 5 and 6 present the associations between cardiorespiratory fitness levels and physical activity categories.

Table 5. Association between Cardiorespiratory Endurance and Pedometer-Based Physical Activity (n=100)

VO_2max Category	Inactive n(%)	Moderately Active n(%)	Physically Active n(%)	Likelihood Ratio	p- value
High (n=14)	0 (0)	4 (28.57)	10 (71.43)	20.051	0.003*
Moderate (n=44)	0 (0)	36 (81.81)	8 (18.18)		
Low (n=42)	3 (7.14)	31 (73.81)	8 (19.05)		
Total	3	71	26		

*Statistically significant at p<0.05

Table 6. Association Between Cardiorespiratory Endurance and GPAQ-Based Physical Activity (n=100)

VO_2max Category	Low Active n(%)	Moderately Active n(%)	Highly Active n(%)	Likelihood Ratio	p- value
High (n=14)	0 (0)	14 (100.0)	0 (0)	10.940	0.004*
Moderate (n=44)	0 (0)	44 (100.0)	0 (0)		
Low (n=42)	6 (14.29)	36 (85.71)	0 (0)		
Total	6	94	0		

*Statistically significant at p<0.05

Significant associations were found between cardiorespiratory endurance and physical activity levels measured by both pedometer (p=0.003) and GPAQ (p=0.004). Among participants with high cardiorespiratory fitness, 71.43% were physically active based on pedometer assessment, compared to only 18.18% of those with moderate fitness and 19.05% of those with low fitness. Similarly, all participants with high and moderate fitness were categorised as moderately active by GPAQ, while 14.29% of those with low fitness fell into the low activity category. The data demonstrates a clear positive correlation: higher levels of cardiorespiratory endurance are associated with greater physical activity levels, and this relationship is evident using both objective and subjective assessment methods.

DISCUSSION

This cross-sectional study examined the association between cardiorespiratory endurance and physical activity levels in overweight individuals using both objective (pedometer) and subjective (Global Physical Activity Questionnaire) assessment methods. The principal findings were that the majority of participants demonstrated suboptimal cardiorespiratory fitness despite being moderately physically active, and that significant positive associations existed between cardiorespiratory endurance and physical activity levels measured by both assessment tools.

Cardiorespiratory fitness in overweight individuals

A key finding of this study was that 86% of participants exhibited moderate to low cardiorespiratory fitness. This observation is consistent with previous literature indicating reduced aerobic capacity among individuals with excess body weight [19,20]. Overweight status is associated with several physiological alterations that negatively affect cardiorespiratory performance, including increased cardiac workload, reduced pulmonary compliance, impaired skeletal muscle oxidative capacity, and chronic low-grade inflammation [39,40]. When VO_2max is expressed relative to body mass, excess adiposity further accentuates reductions in measured fitness levels. The reduced cardiorespiratory fitness observed in this young adult population is clinically relevant, as low aerobic fitness is a well-established independent predictor of cardiovascular disease and all-cause mortality, irrespective of body mass index [17,18]. These findings underscore the importance of assessing fitness alongside anthropometric measures when evaluating cardiovascular risk in overweight individuals.

Physical activity patterns

Although most participants were classified as moderately active based on both pedometer (71%) and GPAQ (94%) assessments, this did not translate into correspondingly high levels of cardiorespiratory fitness. This apparent discrepancy may be attributed to several factors. First, the volume and intensity of physical activity required to elicit meaningful improvements in cardiorespiratory fitness may not have been achieved by individuals categorised as moderately active. While accumulating 5,000–9,999 steps per day reflects engagement in daily ambulation, such activity may be insufficient to induce significant aerobic adaptations, particularly in overweight individuals [42,43]. Second, individuals with excess body weight require a higher relative exercise intensity to achieve comparable metabolic and cardiovascular stimuli compared with normal-weight individuals [44]. Consequently, physical activity levels that are adequate for maintaining health in normal-weight populations may be insufficient for improving aerobic capacity in overweight groups. Finally, although the low prevalence of physical inactivity (<5,000 steps/day) is encouraging, only a quarter of participants achieved recommended daily step counts (≥10,000 steps/day), highlighting substantial scope for increasing overall activity levels.

Association between cardiorespiratory endurance and physical activity

The significant associations observed between cardiorespiratory endurance and physical activity levels support the theoretical and empirical link between habitual activity and aerobic fitness. Participants with high cardiorespiratory fitness were markedly more likely to be physically active, with over 70% achieving ≥10,000 steps per day. These findings align with previous studies reporting moderate associations between step counts and estimated VO_2max across different age groups [45,46]. Physiologically, regular engagement in moderate-to-vigorous physical activity promotes cardiovascular and peripheral adaptations, including increased stroke volume, improved myocardial efficiency, enhanced capillary density, and greater mitochondrial content within skeletal muscle [47,48]. Conversely, individuals with higher baseline fitness may perceive physical activity as less effortful, thereby facilitating greater participation and reinforcing a positive feedback cycle between fitness and activity behavior [49].

Comparison of physical activity assessment methods

An important observation in this study was the discrepancy between physical activity classifications derived from pedometer and GPAQ assessments. The GPAQ classified a greater proportion of participants as moderately active compared with the pedometer, suggesting potential overestimation inherent to self-reported measures. Such discrepancies are well documented and are often attributed to recall bias, social desirability bias, and subjective interpretation of activity intensity [21,50–52]. While pedometers provide objective quantification of ambulatory activity, they are limited in their ability to capture activity intensity and non-ambulatory forms of exercise [23–25]. In contrast, the GPAQ captures activity across multiple domains but relies on participant recall. Despite these limitations, both methods demonstrated significant associations with cardiorespiratory endurance in this study, supporting their complementary utility in assessing physical activity patterns in overweight populations.

Clinical and public health implications

The findings of this study have several practical implications. Simple, low-cost field-based tools such as step tests, pedometers, and questionnaires can be effectively used to screen overweight individuals for low fitness and physical activity levels, particularly in resource-limited or occupational health settings. The observed associations suggest that interventions aimed at increasing daily physical activity—especially progressing toward recommended step counts—may be associated with improved cardiorespiratory fitness. Furthermore, combining objective and subjective assessment methods provides a more comprehensive understanding of physical activity behavior and may enhance individualized exercise prescription and monitoring.

Methodological considerations and limitations

This study has several strengths, including the use of validated assessment tools, standardised measurement protocols, and the inclusion of both objective and subjective physical activity measures. However, certain limitations should be acknowledged. The cross-sectional design precludes causal inference regarding the direction of the observed associations. Physical activity was assessed over a single day using a pedometer, which may not fully reflect habitual activity patterns. Additionally, the use of a submaximal step test to estimate VO_2max, while practical, is less precise than direct cardiopulmonary exercise testing. The relatively young, urban, office-based sample limits generalisability to older adults, rural populations, or individuals with comorbid conditions. Potential confounding factors such as dietary habits, smoking status, and psychosocial variables were not controlled for and may have influenced the observed associations. Future studies employing longitudinal designs, multi-day objective monitoring, and adjustment for relevant confounders are warranted.

Conclusion

This study demonstrates significant positive correlations between cardiorespiratory endurance and physical activity levels in overweight individuals, with associations evident using both objective (pedometer) and subjective (GPAQ) assessment methods. The majority of overweight participants exhibited suboptimal cardiorespiratory fitness (86% moderate or low) despite most being moderately active. Individuals with higher cardiorespiratory fitness were significantly more likely to be physically active, with 71.43% of those with high fitness achieving ≥10,000 steps/day. These findings support the use of simple, practical field-based assessment tools step tests, pedometers, and questionnaires for evaluating fitness and activity relationships in overweight populations. Such tools are valuable for identifying individuals at increased cardiovascular risk and for monitoring responses to physical activity

interventions. The significant correlations observed suggest that promoting increased physical activity, particularly achieving recommended daily step counts, may improve cardiorespiratory fitness in overweight individuals, though longitudinal studies are needed to confirm this relationship.
Healthcare providers and public health professionals should consider routine assessment of both cardiorespiratory fitness and physical activity levels in overweight populations as part of comprehensive risk assessment and management strategies.

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