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Effects of Incremental Shuttle Walk Test on Maximal Oxygen Consumption and Comfort in Patients with Coronary Artery Disease Undergoing Phase 3 Cardiac Rehabilitation

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Abstract

Coronary artery disease (CAD) is a condition characterized by impaired cardiac function due to a reduced blood supply to the myocardial tissue, resulting from narrowing or obstructing of the coronary arteries. This condition can negatively impact the physical, psychological, and social dimensions of the patient's life, often leading to a decline in maximal oxygen consumption (VO2max) and perceived comfort. One solution for increasing the decreased VO2max is cardiac rehabilitation. Cardiac rehabilitation is an effective preventive and recovery intervention that includes assessments of VO2max, and the effects of the incremental shuttle walk test (ISWT) on the VO2max and comfort of CAD patients. This is a quasi-experiment with a pre-post control group design. Consecutive sampling was used to recruit 60 respondents, who were then divided into a control and an intervention group, with 30 respondents in each group. VO2max was measured using the distance achieved in the ISWT, and comfort was assessed using the Shortened General Comfort Questionnaire (SGCQ). Data were analyzed using a paired t test to determine whether the mean pretreatment VO2max and comfort levels significantly changed after the treatment. VO2max and comfort showed significant improvements after the ISWT ($p = 0.001$ for both variables), confirming the effectiveness of ISWT in CAD patients undergoing phase 3 cardiac rehabilitation. Therefore, ISWT should be considered an integral part of cardiac rehabilitation for the management of CAD patients after hospital discharge.

Keywords: comfort, coronary artery disease, incremental shuttle walk test, VO2max

Abstrak

Pengaruh* Incremental Shuttle Walk Test *terhadap Konsumsi Oksigen Maksimal dan Kenyamann Pada Pasien Penyakit Jantung Koroner yang Menjalani Rehabilitasi Jantung Fase 3. *Penyakit Jantung Koroner (PJK) merupakan suatu kondisi yang ditandai dengan gangguan fungsi jantung akibat berkurangnya suplai darah ke jaringan miokardium yang disebabkan oleh penyempitan atau penyumbatan arteri koroner. Kondisi ini dapat berdampak negatif terhadap aspek fisik, psikologis, dan sosial dalam kehidupan pasien, yang sering kali menyebabkan penurunan konsumsi oksigen maksimal* (VO2max) *serta kenyamanan yang dirasakan. Salah satu solusi untuk meningkatkan* VO2max *yang menurun adalah melalui rehabilitasi jantung. Rehabilitasi jantung merupakan intervensi yang efektif dalam pencegahan dan pemulihan, yang mencakup penilaian terhadap* VO2max *serta pengaruh* Incremental Shuttle Walk Test (ISWT) *terhadap* VO2max *dan kenyamanan pasien PJK. Penelitian ini merupakan kuasi-eksperimen dengan desain* pre-post control group*. Pengambilan sampel dilakukan secara* consecutive sampling *terhadap 60 responden yang kemudian dibagi menjadi dua kelompok, yaitu kelompok kontrol dan kelompok intervensi, masing-masing terdiri dari 30 responden.* VO2max *diukur berdasarkan jarak yang dicapai dalam pelaksanaan* ISWT*, sedangkan kenyamanan dinilai* menggunakan Shortened General Comfort Questionnaire (SGCQ)*. Analisis data dilakukan dengan* paired t-test *untuk mengetahui apakah terdapat perubahan yang signifikan pada nilai rata-rata* VO2max *dan tingkat kenyamanan sebelum dan sesudah intervensi. Hasil penelitian menunjukkan adanya peningkatan yang signifikan pada* VO2max *dan kenyamanan setelah intervensi* ISWT *(p = 0,001 untuk kedua variabel), yang menegaskan efektivitas* ISWT *pada pasien PJK yang menjalani rehabilitasi jantung fase 3. Oleh karena itu,* ISWT *sebaiknya dipertimbangkan sebagai bagian integral dalam program rehabilitasi jantung untuk penatalaksanaan pasien PJK pasca perawatan rumah sakit.*

Kata Kunci: incremental shuttle walk test, *kenyamanan, penyakit jantung koroner,* VO2max

Introduction

Coronary artery disease (CAD) refers to impaired heart function caused by reduced blood supply to the myocardial muscle, primarily due to the narrowing or blockage of the coronary arteries (American Heart Association [AHA], 2017). A previous study reported by Hildebrandt et al. (2016) that most CAD patients had a history of risk factors, including obesity (35%), unhealthy lifestyle (30%), hypertension (33%), metabolic syndrome (35%), pre-diabetes mellitus (38%), diabetes mellitus (8.3%), and smoking (20.5%). In addition, most CAD patients exhibited clinical symptoms, such as chest pain, breathlessness, a systolic blood pressure of 100 –150 mmHg, a diastolic pressure > 90 mmHg, a pulse rate of 50–90 beats per minute, an oxy-gen saturation (SpO_2) < 85%, and abnormal levels of high-density lipoprotein, low-density lipoprotein, troponin T, and creatine kinase–myocardial band (Hildebrandt et al., 2016).

CAD and valvular heart disease are major global cardiovascular disorders that significantly impact health-care systems and economic resources, conferring substantial financial burdens to countries worldwide. Cardiovascular diseases remain the leading cause of mortality worldwide. In 2019, they were responsible for approximately 17.9 million deaths, representing 32% of all global deaths. Of the 17 million premature deaths (before the age of 70 years) caused by noncommunicable diseases in the same year, 38% were attributed to cardiovascular diseases (World Health Organization [WHO], 2021). In Saudi Arabia, a national survey reported a prevalence of 5.5% for CAD, which is higher than those observed in India (3%), China (2%), and Europe (5%) (Shafi et al., 2024). In Indonesia, Based on Basic Health Research 2018 reported a 0.5% prevalence of physician-diagnosed coronary heart disease, which affected approximately 83,447 individuals (Badan Penelitian dan Pengembangan Kesehatan, 2019). When based on self-reported symptoms without a physician's diagnosis, the prevalence was 1.5%, or approximately 2,650,340 of all cases. Among the 37 provinces in Indonesia, Jakarta had the second highest prevalence of CAD (0.7%), after Central Sulawesi (0.8%).

A decrease in maximal oxygen consumption (VO2max) is influenced by reduced physical activity capacity, increased dependence on others, and physical strain during activities. VO2max refers to the maximal aerobic capacity, defined as the maximum amount of oxygen consumed per unit of time during progressively intensive exercise up to the point of exhaustion (Lewis et al., 2021). The psychological changes commonly observed in CAD patients include depression, anxiety, suicidal ideation, and feelings of worthlessness. Socially, CAD patients often experience loneliness and isolation, which may hinder their ability to engage in daily activities as desired (Bunevicius et al., 2014).

One cardiac rehabilitation program that has demonstrated numerous positive effects in patients with heart disease is the incremental shuttle walk test (ISWT). This test is considered safe, cost-effective, and practical for assessing cardiac functional capacity, particularly in large groups. In patients with cardiac abnormalities, it not only evaluates VO2max but also provides insights into respiratory, cardiovascular, hematologic, neuromuscular, and muscular metabolic functions, which are factors that collectively influence physical, psychological, and social well-being (Holland et al., 2014).

Several cardiac rehabilitation programs are employed to improve VO2max during the three-phase rehabilitation process, particularly in the maintenance phase. These include the ISWT, cardiopulmonary exercise testing, detection of exercise-induced asthma, and cardiac stress testing (Holland et al., 2014). The ISWT is an externally paced test conducted over a 10-m course, where walking speed is increased every minute until the patient becomes too breathless or fatigued to continue, or is unable to maintain the required pace.

Several studies have demonstrated that the ISWT has positive effects on patients' physical, psychological, and social aspects. The ISWT has been associated with significant improvements in serum lactate level, N-terminal pro–brain natriuretic peptide level, heart rate, resting systolic and diastolic blood pressures, respiretory function, QRS duration, hemoglobin level, urea level, creatinine level, peak SpO_2, and peak VO2max (Hayward et al., 2015; Ingle et al., 2014). Moreover, patients showed an improved ability to perform physical activities independently and enhanced cognitive and emotional functioning. In terms of social impact, the ISWT fostered mutual support among participants during training sessions and contributed to increased self-confidence (Rejeski et al., 2014; Tully et al., 2016). The effects of the ISWT on CAD patients' VO2max and perceived comfort have not been thoroughly investigated. As a result, its potential benefits remain underecognized among CAD patients.

Methods

This study used a quasi-experimental design with a pre-post-test and control group. Sixty (60) participants were selected using random sampling and assigned to either the intervention group (n = 30) or control group (n = 30). The study was conducted from August 21 to September 30, 2023, at the South Jakarta Regional Health Center. The intervention group received the ISWT protocol in addition to standard care, while the control group received only standard care without the ISWT. The ISWT followed the standardized procedure described by Holland et al. (2014), in which participants walk back and forth along a 10-meter course with gradually in-creasing speed guided by audio signals. VO2-max was estimated using a validated prediction formula based on the distance achieved during the ISWT (for the intervention group). Comfort was measured using the Shortened General Comfort Questionnaire (SGCQ), which had been tested for validity and reliability, with a Cronbach alpha value of 0.840 (≥ 0.7), which indicates good internal consistency. The reli-ability coefficient was r = 0.917, which exceed-ed the acceptable range of r = 0.411–0.708.

This study received ethical approval from the Health Polytechnic of Yogyakarta and formal permission from the South Jakarta Regional Health Center. The data used in this study were analyzed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY). A univariate analysis was performed to describe the distribution of each variable. and the bivariate analysis was performed using a paired t-test to examine differences in the dependent variables, VO2max and comfort, before and after the treatment. The level of statistical significance was set at $p < 0.05$, and the normality assumptions were tested using the Shapiro-Wilk test prior to conducting parametric tests.

Results

The aim of this study was to examine the demographic and clinical characteristics of the participants in both the intervention and control groups to ensure comparability before the intervention. These characteristics include sex, age, body mass index (BMI), and smoking status. Understanding these baseline profiles is essential for accurately interpreting the outcomes of the intervention.

Table 1 shows that most participants in the control group were female, accounting for 22 (73.3%) of the 30 participants. In the intervention group, 15 of the 30 participants (50.0%) were female. Regarding age distribution, the largest proportion of the participants in the control group were aged 56–65 years and > 65 years, with each age group consisting of 15 participants (50%) and 11 participants (36.7%) respectively. Of the 30 participants in the intervention group, 8 (26.7%) were aged > 65 years. In terms of BMI status, most participants were classified as obese, with 14 participants (46.7%) in the intervention group and 13 (43.3%) in the control group having an obese BMI status.

Table 1. Patients' Characteristics

Variable	Intervention		Control		Total	
	n	%	n	%	n	%
Sex						
Male	15	50.0	8	25.7	23	38.3
Female	15	50.0	22	73.3	37	61.7
Age (years)						
45–55	15	50.0	4	13.3	19	31.7
56–65	7	23.3	15	50.0	22	36.7
>65	8	26.7	11	36.7	19	31.7
Body mass index						
Under weight	1	3.3	0	0.0	1	1.7
Normal weight	10	33.3	11	36.7	21	35.0
Overweight	5	16.7	6	20.0	11	18.3
Obesity	14	46.7	13	43.3	27	45.0
Smoking						
Yes	7	23.3	9	30.0	16	26.7
No	23	76.7	21	70.0	44	73.3

Table 2. Patients' Distance Traveled, VO_2max, and Comfort Before and After the ISWT

Time	Variable	Group	Mean	Median	SD	Range	95% Confidence Interval
ISWT Early	Mileage	Intervention	225.03	227.00	44.28	53–283	208.50–241.57
		Control	257.47	270.00	45.37	155–343	240.53–274.41
ISWT Final	Mileage	Intervention	332.20	351.00	80.29	96–446	302.22–362.18
		Control	280.07	278.50	52.12	194–414	260.60–299.53
ISWT Early	VO_2max	Intervention	10.73	10.79	1.32	5.57–12.47	10.23–11.22
		Control	11.70	12.08	1.85	8.63–14.27	11.19–12.21
ISWT Final	VO_2max	Intervention	13.94	14.51	2.41	6.86–17.36	13.04–14.84
		Control	12.38	12.33	1.56	9.80–16.40	11.79–12.96
ISWT Early	SpO_2 before ISWT	Intervention	98.23	98.00	0.97	95–99	97.87–98.60
		Control	98.33	99.00	1.06	95–99	97.94–98.73
	SpO_2 after ISWT	Intervention	98.97	99.00	1.00	96–102	98.23–98.97
		Control	98.53	99.00	0.68	97–99	98.28–98.79
ISWT Final	SpO_2 before ISWT	Intervention	98.17	98.00	0.83	97–99	97.86–98.48
		Control	97.27	97.50	0.96	96–99	97.27–97.99
	SpO_2 after ISWT	Intervention	98.27	98.00	0.64	97–99	98.03–98.51
		Control	97.83	98.00	0.74	97–99	97.55–98.11
ISWT Early	Comfort	Intervention	79.70	81.50	5.15	68–87	77.78–81.62
		Control	79.87	80.50	5.33	68–90	77.87–81.86
ISWT Final	Comfort	Intervention	108.63	110.00	9.01	89–130	105.27–112.00
		Control	84.22	84.00	3.15	78–91	83.06–85.41

As presented in Table 2, the mean distance covered by the participants in the intervention group during the initial ISWT was 225.03 m, which increased to 332.20 m after the final ISWT. In the control group, the mean distance improved modestly, from 257.47 m at baseline to 280.07 m post-intervention.

Regarding VO2max, the intervention group demonstrated an increase from a mean of 10.73

mL/kg/min at baseline to 13.94 mL/kg/min after the final ISWT. In comparison, the control group exhibited a smaller improvement, from 11.70 mL/kg/min to 12.38 mL/kg/min.

For oxygen saturation (SpO_2), the intervention group had a pre-ISWT mean of 98.23% and a post-ISWT mean of 98.97% at baseline, and 98.17% before and 98.27% after the final ISWT. The control group showed pre- and post-ISWT saturation levels of 98.23% and 98.53% at baseline, and 97.27% and 97.83% after the final ISWT, respectively. Overall, all the participants maintained normal SpO_2 levels (> 95%) throughout the study.

Comfort levels, as assessed using the SGCQ, increased significantly in the intervention group from a baseline mean score of 79.70 to 108.63 post-intervention. In the control group, the mean comfort score also increased, albeit to a lesser extent, from 79.87 to 84.22.

As shown in Table 3, the bivariate analysis results indicated a notable improvement in VO2max within the intervention group. The mean VO2max increased from 10.73 mL/kg/min before the ISWT to 13.95 mL/kg/min after the intervention. In the control group, VO2max also increased, albeit to a lesser extent, from 11.70 mL/kg/min to 12.38 mL/kg/min. The statistical analysis revealed a significant difference in VO2max both within and between the intervention and control groups before and after the ISWT, with p values < 0.05 ($p = 0.001$ and $p = 0.043$, respectively).

Similarly, comfort levels, as assessed using the SGCQ, showed significant improvements in the intervention group, with the mean score increasing from 79.70 at baseline to 108.63 post-intervention. By contrast, the control group experienced a smaller increase in comfort, from 79.87 to 84.23. The difference in comfort scores before and after the ISWT between the two groups was statistically significant, with a p value of 0.001 for both variables.

Table 4 presents the results of the bivariate analysis for comparison of the mean differences before and after the intervention. The mean change in VO2max in the intervention group was 3.21 mL/kg/min, whereas that in the control group was 0.68 mL/kg/min. The statistical analysis confirmed a significant difference in VO2max change between the two groups, with a p value of 0.001 ($p < 0.05$). Similarly, the mean difference in comfort score, as measured with the SGCQ, was 28.93 points in the intervention group and 4.37 points in the control group. This difference was also statistically significant, with a p value of 0.001 ($p < 0.05$), indicating a greater improvement in comfort among the participants who underwent the ISWT intervention.

Table 3. Differences in the Patients' VO2max and Comfort Before and After the ISWT

Variable	Group	n	Mean	SD	p
VO2max	Intervention				
	Pre-ISWT	30	10.73	1.3	0.001
	Post-ISWT	30	13.95	2.41	
	Control				
	Pre-ISWT	30	11.70	1.36	0.043
	Post-ISWT	30	12.38	1.56	
Comfort	Intervention				
	Pre-ISWT	30	79.70	5.15	0.001
	Post-ISWT	30	108.63	9.01	
	Control				
	Pre-ISWT	30	79.87	5.34	0.001
	Post-ISWT	30	84.3	3.15	

Table 4. Analysis of the Differences in VO2max and Comfort Between the Control and Intervention Groups Before and After the ISWT

Variable	Group	n	Mean	SD	p value
VO2max	Intervention	30	3.21	1.85	0.001
	Control	30	0.68	1.76	
Comfort	Intervention	30	28.93	7.97	0.001
	Control	30	4.37	3.95	

Discussion

The ages of the participants in this study were relatively similar. Most participants in the control group were between 56 and 65 years old, with a mean age of 64.2 years, while those in the intervention group were between 45 and 55 years old, with a mean age of 55.1 years. These age characteristics are consistent with the findings of Rodrigues et al. (2015), who reported that most individuals who participated in the ISWT were between 60 and 65 years of age. Theoretically, age plays a significant role in the development of arterial diseases, as it is associated with structural and functional changes in the arteries, including reduced lumen diameter, increased arterial wall thickness, greater arterial stiffness, and alterations in endothelial function (Rodrigues et al., 2015).

Most respondents in this study were female, comprising 22 patients (73.3%) in the control group and 15 (50%) in the intervention group. These findings differ from those of So (2015) study, which reported that 80% of the 30 respondents were male (24 males and 6 females). This discrepancy may be attributed to the differences in population characteristics and research contexts between the studies. Owing to the predominance of male participants, So (2015) study might have reflected higher levels of physical activity. By contrast, the present study included more females because the participants were recruited from health-care facilities where the proportion of female patients, particularly among older adults, was higher, as women are more likely to access cardiac rehabilitation services. In addition, gender differences may be influenced by social roles, risk perceptions, and the willingness to participate in intervention programs. So (2015) study found a significant association between sex and VO2max ($p = 0.001$; $\alpha = 0.05$), indicating that sex can affect cardiorespiratory capacity. Therefore, the sex distribution observed in this study should be considered when interpreting the intervention outcomes in terms of VO2max.

Theoretically, females have an approximately 20% lower VO2max capacity than males. This difference is primarily attributed to hormonal variations, which result in lower hemoglobin concentrations and higher body fat percentages in females. In addition, females typically have less muscle mass than males (Wan et al., 2015). VO2max differences between the sexes become evident from around the age of 10 years, with boys exhibiting a 12% higher VO2max than girls. By age 12 years, the gap increases to approximately 20%, and by age 16 years, boys' VO2max is approximately 37% higher than that of females (Wan et al., 2015).

Smoking is one of the most common risk factors of CAD in male patients. However, most respondents in this study were nonsmokers, as all female participants in both the control (70%) and intervention groups (76.7%) were nonsmokers. These findings are consistent with a previous study by Bajaj et al. (2016) in Punjab, North India, where 44% of male respondents were smokers, and none of the female respondents smoked. This pattern may be influenced by sociocultural norms, where smoking among women is less socially acceptable. Despite not smoking, female patients may still develop CAD due to other risk factors, such as hypertension, high cholesterol, hyperlipidemia, diabetes mellitus, and a family history of CAD. These findings are consistent with other studies conducted in regions where smoking is uncommon among female populations (Bajaj et al., 2016). In the present study, the statistical analysis revealed a significant correlation between smoking status and VO2max among the CAD patients, with a p value of < 0.001 ($\alpha = 0.05$).

The findings of this study differ from those reported by Nery et al. (2015) that showed that 42% of respondents in the control group and 50% of those in the intervention group were smokers. By contrast, in the present study, only 23.3% of the patients in the intervention group and 30.0% of those in the control group were smokers. Nery et al. (2015) also identified a significant correlation between smoking status and VO2max in CAD patients, with a p value of < 0.001, suggesting that smoking negatively impacts cardiorespiratory fitness. This inconsistency may be explained by demographic and cultural differences, particularly regarding gender-related smoking behaviors. Supporting this, in a study involving 94 smokers, Mohammad et al. (2015) reported that smoking was less prevalent among women, noting that smoking remains relatively uncommon in female populations. In the present study, the higher proportion of female participants might have contributed to the lower overall smoking rates observed. Therefore, the sex composition of the sample likely influenced the prevalence of smoking and should be considered when analyzing the relationship between smoking and VO2max in CAD patients.

The results of this study show that the BMI statuses of the 30 patients in the intervention group and most of the patients in the control group indicated obesity. In particular, 14 patients (46.7%) in the intervention group and 13 (43.3%) in the control group were classified as obese. According to BMI classification, a person is considered obese if their BMI exceeds 30 kg/m2. Obesity is associated with increased blood volume and cardiac output, which result from higher metabolic activity and adipose tissue accumulation. These factors can lead to hemodynamic changes in CAD patients, such as left ventricular remodeling, increased myocardial wall stress, and physical discomfort (Plourde et al., 2014). A study conducted at the University Hospital in Gyeonggi-do, South Korea, from January 2, 2010, to December 31, 2012, found that age and BMI significantly correlated with an increased risk of CAD (Lee et al., 2015).

Effect of ISWT on VO2max. The results of this study show that the mean VO2max measurement in the intervention group was 10.73 ± 1.33 mL/kgBW/min before ISWT and 13.95 ± 2.41 mL/kgBW/min after ISWT. Meanwhile, the mean (±SD) VO2max measurement in the control group was 11.70 ± 1.36 mL/kgBW/min before ISWT and 12.38 ± 1.56 mL/kgBW/min after ISWT. The statistical results indicate significant differences in mean VO2max before and after ISWT in both groups ($p < 0.001$ and $p = 0.043$).

Theoretically, several physiological responses associated with physical activity training occur in the heart, including increased heart rate, changes in stroke volume, alterations in blood flow distribution during exercise, and long-term adaptations resulting from training. Appropriate physical activity can enhance the efficiency of oxygen exchange at the tissue and skeletal muscle levels, thereby increasing VO2-max, improving cardiorespiratory capacity, and optimizing lung expansion. VO2max typically peaks after 3 months of ISWT training, with improvements ranging from 10% to 30% and a mean increase of 20% (Nery et al., 2015). According to the results of a systematic review by Oliveira et al. (2014), the relationship between the ISWT and VO2max is moderate to strong. In another study, the ISWT demonstrated 83% to 91% accuracy in predicting VO2max at distances between 450 and 490m (Tilborg et al., 2014).

The improvement in VO2max observed in this study is in line with the results of Osailan et al. (2023) who investigated myocardial function and cardiopulmonary responses using the ISWT and a treadmill-based ISWT (ISWT-T). Their study reported no significant differences in cardiopulmonary parameters between the two testing modalities, except for VO2max, which was higher in the ISWT group (25.4 ± 5.8 vs. 23.7 ± 5.1; $p = 0.05$). They also found that age and height were significantly correlated with the distance achieved in both the ISWT and ISWT-T (age: $r = -0.72$ vs. -0.73, $p \leq 0.05$; height: $r = 0.68$ vs. 0.68, $p \leq 0.05$), while leg length was only correlated with the distance achieved in the ISWT-T ($r = 0.59$, $p \leq 0.05$).

The type of intervention and therapy that patients with CAD receive influences their heart functional capacity. For example, Lewis et al. (2021) reported a lower mean heart functional capacity compared to that reported by Osailan et al. (2023). This difference may be attributed to the characteristics of the patient population in Lewis et al. (2021) study, in which participants had anterior and inferior myocardial infarctions and received more intensive treatments, including coronary artery bypass grafts, percutaneous coronary interventions, beta-blockers, Angiotensin-Converting Enzyme (ACE) inhibitors, statins, and anticoagulants. In contrast, the patients in the present study had less severe conditions and received different therapeutic regimens. Additionally, variations in age and clinical history may have contributed to the observed differences in functional capacity outcomes.

Several studies have yielded meaningful results despite variations in the types of exercises and tests used to assess heart functional capacity. In a study on Tai Chi Chuan exercise, Nery et al. (2015) reported a significant increase in VO2-max from 21.6 ± 5.2 mL/kg body weight/min to 24.6 ± 5.2 mL/kg body weight/min in the intervention group, indicating an improvement of 14%. A statistical analysis indicated a significant difference in heart functional capacity between the two groups ($p < 0.001$).

Effect of the ISWT on Comfort. Daily activities are influenced by a person's physical fitness. A person's functional capacity can be assessed using several parameters, such as maximum oxygen uptake, metabolic equivalents of task, and training distance traveled. The training test generally performed is the 6-min walking test (6MWT), while the training test that is now widely used is the ISWT. The advantage of the ISWT is that it is externally paced; thus, it can reflect a person's exercise tolerance better than the 6MWT. Various factors influence cardiorespiratory fitness, including humidity, temperature, hemoglobin level, and blood lactate levels, as well as demographic and Anthropometric characteristics, such as age, sex, height, and weight. This research focuses on demographic and anthropometric factors.

The comfort of CAD patients in the control group was assessed using the SGCQ, and the results were statistically significant. Before the ISWT intervention, the control group had a mean (±SD) score of 54.2 ± 6.4, which increased to 58.0 ± 6.3 after the intervention. In the intervention group, the mean (±SD) score before the ISWT treatment was 53.4 ± 5.6, which increased to 61.6 ± 5.2 after the treatment.

Physical comfort plays a central role in influencing both physiological and psychological aspects of comfort. These three dimensions are strongly correlated. For instance, physical pain can trigger negative emotions such as depression and anxiety, which in turn may worsen physiological responses. Conversely, psychological states such as happiness and relaxation can help reduce physical discomfort. Therefore, improving physical comfort can lead to enhanced physiological and psychological well-being (Krinsky et al., 2014; Pedrazza et al., 2015).

However, this study has several limitations that must be acknowledged, as they could affect the interpretation and generalizability of the findings. First, the sample size of 60 patients (30 in each group) limited the statistical power and external validity of the results. A larger sample would have provided more robust estimates and allowed for subgroup analyses. Second, the age range and sex distribution of the participants, most of whom were female and middle-aged to elderly, might have limited the generalizability of the findings to younger populations or male-dominant CAD cohorts. Cultural and behavioral differences, such as the low prevalence of smoking among the female participants, also reflect region-specific patterns that may not be applicable to broader or more diverse populations.

In spite of these limitations, the study contributes theoretical insights to nursing practice by supporting the physiological and psychological benefits of structured exercise interventions, particularly the ISWT, in the management of CAD patients. The findings align with the theoretical framework that links improved oxygen uptake, cardiovascular efficiency, and physical comfort to enhanced functional capacity and quality of life in patients with chronic CAD. The increased VO2max and comfort scores in the intervention group confirm that the ISWT can be integrated into cardiac rehabilitation programs, with nursing professionals playing a pivotal role in monitoring progress and ensuring adherence.

In clinical practice, nurses can use the ISWT as a standardized, cost-effective, and easy-to-administer tool for assessing exercise tolerance and guiding individualized care plans. Moreover, understanding the interplay between physical fitness, comfort, and patient demographics enables nurses to deliver more holistic and patient-centered interventions. Future research is recommended to examine the long-term effects of the ISWT in larger, more-heterogeneous samples and to explore psychosocial variables that influence comfort and rehabilitation outcomes in CAD patients.

Conclusion

The results of this study demonstrate that the ISWT can significantly improve cardiac functional capacity and enhance patient comfort. This was evidenced by the statistical analysis results that showed significant differences in the changes in VO2max and comfort levels between the control and intervention groups ($p < 0.05$).

These findings suggest that the ISWT program has a positive impact on improving VO2max and comfort of the CAD patients in this study during cardiac rehabilitation. Thus, it can be effectively integrated into nursing services, particularly in heart health clubs. Future studies should explore alternative or modified rehabilitation programs to further improve VO2max and comfort in CAD patients.

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