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Research Article / Araştırma Makalesi

Home-based bench step exercise program with Smart Step Board: a comparative pilot study

Akıllı step tahtası ile ev tabanlı bench step egzersiz programı: karşılaştırmalı pilot çalışma

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ABSTRACT

Objective: To compare the effect of home-based step aerobic exercise program on physical fitness in sedentary university students with a control group.

Materials and Methods: This study is a quasi-experimental design comparing two groups, pretest-posttest and follow-up test. The sample consists of 25 sedentary female university students between the ages of 18-25. The home-based step aerobic exercise group (14 students) participated in supervised step aerobic exercise intervention three days a week for six weeks. The control group (11 students) was not included in any intervention. Resting heart rate (rHR), heart rate recovery (HRR), jump performance, 6-minute walking distance (6MWD), Flamingo balance test score, quadriceps muscle strength and exercise motivation of participants were assessed.

Results: After the exercise program, significant improvements in physiological parameters including rHR and HRR, and in 6MWD, quadriceps muscle strength, jump height, and balance scores led to an overall improvement in functional exercise capacity, endurance, and strength ($p<0.05$). However, the results obtained at the four-week follow-up evaluation displayed that this current improvement was not maintained for all parameters except RHR, HRR and balance ($p<0.05$). For the control group, the above parameters did not change over time ($p>0.05$).

Conclusions: Sedentary university students participating in a 6-week home-based step aerobic exercise program can improve their physical and physiological functions by using a smart step board, chest heart rate band, and mobile application. Effects of post-exercise on RHR and HRR may be maintained for four weeks.

Keywords: *Aerobic exercise, heart rate, physical fitness, postural balance*

ÖZ

Amaç: Sedanter üniversite öğrencilerinde ev tabanlı step aerobik egzersiz programının fiziksel uygunluk üzerindeki etkisini kontrol grubu ile karşılaştırmaktır.

Gereç ve Yöntemler: Bu çalışma, iki gruplu ön test-son test ve izlem testini içeren yarı deneysel bir tasarımdır. Araştırmanın örneklemini 18-25 yaş arası 25 sedanter kadın üniversite öğrencisi oluşturdu. Ev tabanlı step aerobik egzersiz grubu (14 öğrenci) altı hafta boyunca haftada üç gün, denetimli step aerobik egzersiz programına katıldı. Kontrol grubuna (11 öğrenci) ise herhangi bir girişim uygulanmadı. Tüm katılımcıların istirahat kalp hızı (İKH), kalp atım hızı iyileşmesi (KHİ), sıçrama performansı, 6 dakika yürüme mesafesi (6DYM), Flamingo denge testi skoru, quadriceps kas kuvveti ve egzersiz motivasyonu değerlendirildi.

Bulgular: Egzersiz programı sonrası İKH ve KHİ'yi içeren fizyolojik parametrelerde ve 6DYM, quadriceps kas kuvveti, sıçrama yüksekliği ve denge skorlarında elde edilen anlamlı gelişmeler, fonksiyonel egzersiz kapasitesi, endürans ve kuvvette genel bir iyileşmeyi gösterdi ($p<0.05$). Ancak dört haftalık izlem değerlendirmesinde elde edilen sonuçlar, DKH, KHİ ve denge dışındaki tüm parametreler için bu iyileşmenin korunmadığına işaret etti ($p<0.05$). Kontrol grubu için yukarıdaki parametreler zamana bağlı olarak değişiklik göstermedi ($p>0.05$).

Sonuç: Evde altı haftalık aerobik egzersiz programına katılan sedanter üniversite öğrencileri, akıllı step tahtası, göğüs nabız bandı ve mobil uygulama kullanarak fiziksel ve fizyolojik fonksiyonlarını geliştirebilirler. Egzersiz sonrası İKH ve KHİ üzerindeki etki dört hafta sürebilir.

Anahtar Sözcükler: *Aerobik egzersiz, kalp hızı, fiziksel uygunluk, postüral denge*

INTRODUCTION

In recent years, unhealthy lifestyle behaviours have been increasing and individuals are embracing a more sedentary lifestyle (1,2). On the other hand, most individuals are aware that physical activity and exercise are beneficial to lead a healthful life (3). However, half of people who start exercise quit between three and six months (4) because of exercise limitations such as distance (5) and lack of motivation (6). Thus, innovative solutions should be produced to increase the attendance and continuity of individuals in exercises.

To increase the participation of individuals in exercise and to implement innovative exercise interventions, new products were developed by the sports and exercise industry

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towards the end of the 1980s. The first product is a platform known as 'bench' or 'step aerobics' (7). The second is the wireless, wearable heart rate monitor (HRM) developed for HR monitoring, consisting of dry electrodes mounted on a chest strap sensor, and a wristwatch radio receiver (8,9). Electrocardiograms are considered as the gold standard to determine exercise intensity but comparing withelectrocardiograms, HRM is more advantageous as it is easy to monitor, relatively inexpensive, and applicable in most cases (8,10,11). Also, HR parameters which are considered as an important indicator of physiological response to exercise, play a role in the analysis of exercise tests, adjusting training intensity, and planning wearable health monitoring-devices (8,10).

Opportunities for an economical and effortlessly applicable home-based exercise intervention for both healthy and chronically ill people is offered by the growing and evolving market of smartphone applications and wearable technological devices (12,13). Yet, health practitioners are sometimes challenged with monitoring exercise intensity of home-based exercises, and performing the exercise in the safe limit. Even a false step/bench exercise performed at homewith a simple exercise equipment can increase the risk of injury (7).

A local exercise product developer integrated a step board with a chest HR band, thus modifying the step board into a smart step board. This innovative design caught our attention as it helps people safely and effectively performing step aerobic exercises within the targeted HR range. Therefore, we designed a pilot study using the smart step board. In this pilot study, a home-based step aerobic exercise intervention that includes the use of the smart step board was prepared for sedentary university students, and the aim was to compare their physical fitness characteristics with the control group, after the intervention.

MATERIALS and METHODS

Study Design, Procedures and Participants

This study was a two-group pretest-posttest follow-up quasi-experimental design using purposive sampling. The study was conducted on 25 sedentary female students aged between 18-25 years. Participants were invited to the study using a Google forms link containing brief information about the study. The participants' sedentary behavior was assessed by self-report measurements (the participation in exercise sessions in the last six months).

Inclusion criteria: (i) being between the ages of 18-25, (ii) being female, (iii) having a doctor's consent declaring that it does not prevent them from exercising, and (iv) owning and using a smartphone, tablet or computer.

Exclusion criteria: (i) presence of metabolic, cardiovascular (CV), neurological, musculoskeletal or disease, (ii) not engaging in endurance exercise training, (iii) current use of any medication influencing the CV system, and (iv) body imbalance due to loss of consciousness or dizziness.

Study groups were determined after obtaining participants' informed consent. All participants, and raters ETH and GT were blind to study group assignments, which was based on exercise motivation of the students. Exercise motivation was assessed with a self-report measure (between 0-100 points) (14). The participants' average exercise motivation score when they were invited to the study was 70. Those scoring above 70 were included in the home-based step aerobic exercise group (HG in 14 students), and those scoring under 70 were included in the control group (CG in 11 students). Figure 1 displays the study flow diagram.

Step Aerobic Home Exercise Model and Intervention

In this study, Smart Software Health Inc. Company's Smart Step® device was used. This device connects to a chest HR band (Chileaf CL 800) to measure HR, and a smartphone app (SH Life) to monitor target HR via bluetooth. The intervals of the LED lights on the smart step board were defined according to the HR reserve: yellow, 50-60%; green, 60-70%; blue, 70-80%; orange, 80-90%; red, 90-100%. The corresponding color codes of HR changes during the exercise sent feedback to the mobile app and step board. The target HR intensity determined for this study was limited to 50-70% of each individual's HR reserve (yellow and green zones). The individual was asked to decrease his/her tempo when the blue light on the step board was on and increase it when the yellow light was on.

A 6-week, 3-days-a-week, supervised step-aerobic exercise intervention was conducted in HG. Main duration was 50 min/per session, including 5-min warm-up and cool-down exercises. The intervention included basic aerobic-step exercises in three circuit sequences, including a few minutes of rest (15). Exercise participation rate was 100%. A new session was added, again every other day, in the same week, for any training session that was missed.

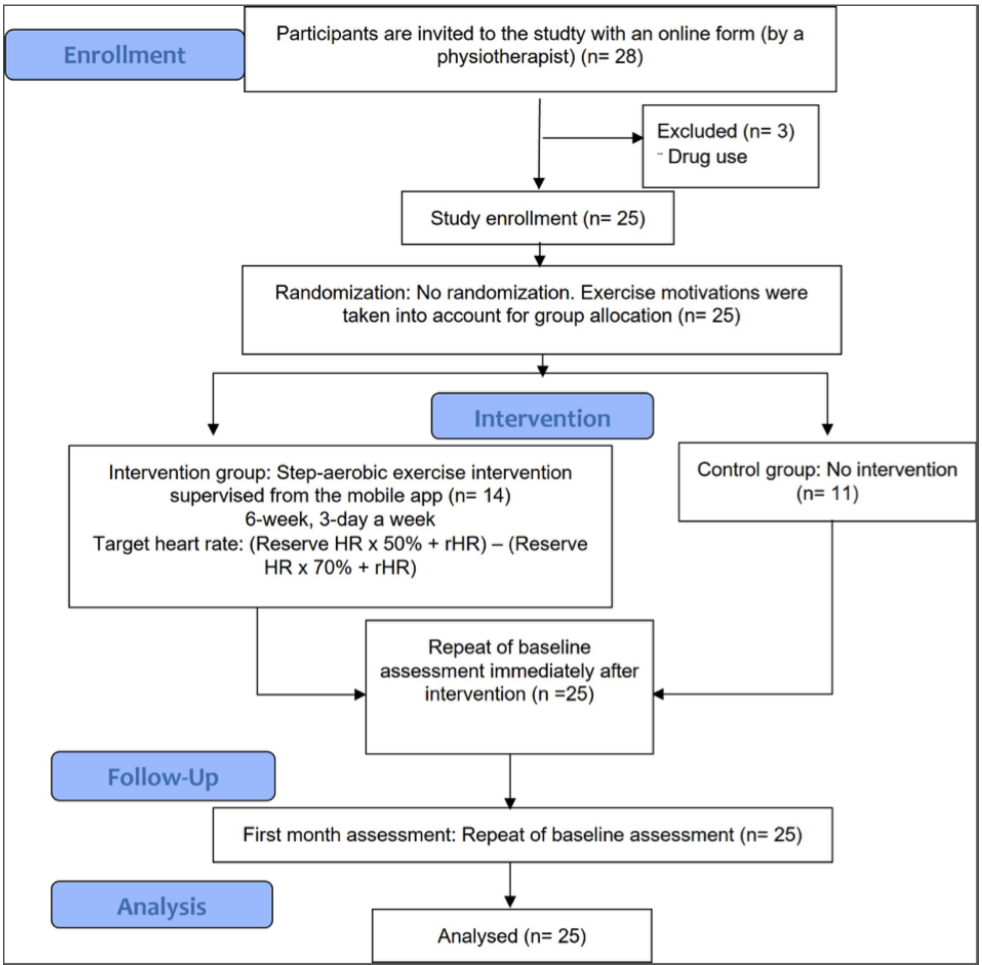

Figure 1. Study flow diagram. HR: heart rate, rHR: resting heart rate

Outcome Measures

A body composition analyzer (TANITA BC 601 Ltd, Paris, France) was used to measure body mass index, total body water, body fat mass, and fat mass ratio. For consistency, measurements were taken in light clothing, with an empty bladder. HR changes and physical fitness parameters were measured in all participants three times: baseline assessment (pre-test, T1), post-test (T2), and 4-week follow-up test (T3). ETH measured jump performance and 6MWT parameters; other parameters were measured by GT.

Six minute walk test (6MWT): This is a submaximal test used to evaluate aerobic capacity and endurance (16). Walking distance was assessed using a three-axis accelerometer (G-Sensor, BTS Bioengineering SpA, Italy) attached to the S1-S2 intervertebral space using a semi-elastic belt (17). In addition, HR data were recorded with a pulse oximeter before, immediately after, and one minute after the test.

Resting HR (rHR): Participants were asked to measure and record their rHR the day before and the morning of all assessments. HR was measured in the morning within one hour of waking up, before breakfast or taking any medication, in a seated position and resting for at least 2 min (18). The measurement was obtained over the radial artery.

Maximum HR: According to the Karvonen formula, as 220-age.

HR recovery (HRR): Defined as the difference between the participant's HR at the end of the 6-minute walking test and the first minute of recovery (19). A standard pulse oximeter was used for measurement.

Target HR: Exercise intensity of 50-70% of the participant's HR reserve was targeted according to the Karvonen formula.

Balance measurement: The Flamingo Balance Test was used for static balance measurement. The validity and reliability of the test and ICC value (0.71) were reported in a study (20). The times the participants fell in one minute were calculated while trying to balance on a 15 cm height and 4 cm wide wooden plate (21).

Isometric strength testing of the quadriceps muscle: Quadriceps' maximum isometric strength was evaluated with adynamometer (Baseline®, Fabrication Enterprises, United

States). Measurements were conducted on the dominant extremity and in an upright sitting position. The highest value obtained from three repetitions was recorded as maximum muscle strength.

Jump performance: Jump performance was evaluated with the countermovement jump test using a wireless inertial sensing device (G-Sensor, BTS Bioengineering S.p.A., Italy). The device has near-perfect test-retest reliability in jump measurements. Our measurements were performed following the guidelines in a previous study (22).

Exercise motivation: Participants verbally reported their exercise motivation, giving a score of 0-100. Higher scores indicated higher exercise motivation.

Statistical Analysis

Statistical analyses were performed using SPSS Statistics 25 (v20.0, IBM Corp., Armonk, NY, US) and JASP (v0.16.3, https://jasp-stats.org). The Shapiro-Wilk test was used to verify normal distribution of variables. Accordingly, most variables revealed normal distribution. Baseline characteristic data were analyzed using the t-test or Mann-Whitney U test. Intragroup results were analyzed by repeated measures analysis of variance (ANOVA) to compare T1, T2 and T3; the Friedman test was applied to analyze values not normally distributed. The between-subject factor was groups and the within-subject factor was time (pre- and post-test, and follow-up). If the ANOVA or Friedman test was significant, a paired t-test or a Wilcoxon test was performed to identify the source of differences. Bonferroni correction was used to counteract the multiple comparisons problem. An α level of p=0.05 was defined for statistical significance.

RESULTS

Baseline characteristics and body composition analysis of the participants are presented in Table 1. No between-groups differences existed for mean age, height, and body composition.

Table 1. Baseline characteristics and body composition analysis of participants before the intervention.

Variables	Total (n=25)	HG (n=14)	CG (n=11)	p
Age (yrs)	21.1±0.9	21.1±0.9	21.1±0.9	0.885[a]
Body mass (kg)	56.3±5.5	55.4±5.1	57.3±6.0	0.742[a]
Height (cm)	164.0±5.5	164.0±5.8	165.0±5.1	0.447[b]
BMI (kg/m²)	20.8±1.9	20.7±1.8	20.1±2.0	0.769[b]
Fat mass ratio (%)	25.2±5.0	24.2 ± 5.6	26.5±4.0	0.467[a]
Fat mass (kg)	14.4±4.1	13.6 ± 4.0	15.5±4.1	0.609[a]
Fat free mass (kg)	41.9±2.3	41.9±2.3	42.0±2.4	0.890[b]
Total body water (l)	30.8±1.8	30.7±1.7	31.0±1.9	0.631[b]
MTE (score)	69.5±13.0	78.2±4.3	58.5±12.0	<0.001[a]

HG: home-based exercise group, CG: control group, MTE: motivation to exercise. Data presented as mean±SD; [a]: performed by Mann-Whitney U test, [b]: performed by t-test.

Time-based Measurements of the Exercise Group

HG participants improved or maintained all measures from T1 to T2 (Table 2). At T2 there were significant increases in HRR, 6MWD, countermovement jump (CMJ) height, quadriceps strength and exercise motivation compared with T1. At T2 there were significant decreases in rHR and Flamingo balance scores. HG differed significantly from T2 to T3 for rHR, 6MWD and exercise motivation. HG improved significantly from T1 to T3 in two measures. At T3, there was a significant decrease in HRR and Flamingo balance scores from T1. There was no change in the 6MWD, CMJ height, quadriceps strength, and exercise motivation.

Time-based Measurements of the Control Group

Exercise motivation of the CG increased significantly from T1 to T3 and T2 to T3 (Table 3).

Table 2. Comparison of physiological and physical measurements of the home-based exercise group at pre-test, post-test and 4-week follow-up

Variables	Pre-test[a]	Post-test[b]	4-wk fw-up[c]	F & X^2	p, multiple	p, post hoc
rHR (bpm)	72.6±4.0	65.1±6.1	68.2±7.4	21.875	**<0.05***	**<0.05[a,b;a,c]** **<0.05[b,c]**
6MWD (m)	535±34	564±30	542±25	12.658	**<0.05***	**<0.05[a,b;b,c]** >0.05[a,c]
HRR (bpm)	23.3±6.5	32.4±6.0	28.7±7.1	15.230	**<0.05***	**<0.05[a,b;a,c]** >0.05[b,c]
Flamingo BT(score)	10.0±4.28	4.93±2.50	6.86±3.92	16.580	**<0.05***	**<0.05[a,b;a,c]** >0.05[b,c]
CMJ height (cm)	19.3±2. 9	22.0±2.9	20.7±2.9	9.108	**<0.05***	**<0.05[a,b]** >0.05[a,c;b,c]
Quad strength (kgf)	13.1±2.3	14.6±1.8	12.9±1.9	10.396	**<0.05***	**<0.05[a,b]** >0.05[a,c;b,c]
MTE (score)	78.2±4.3	83.3±7.5	78.6±7.6	13.535	**<0.05***	**<0.05[a,b;b,c]** >0.05[a,c]

*: statistical significance, Bonferroni-corrected. Data are presented as mean±SD. rHR: resting heart rate, HRR: heart rate recovery, BT: balance test, CMJ: counter movement jump, Quad: quadriceps, MTE: motivation to exercise.

Table 3. Comparison of physiological and physical measurements of the control group at pre-test, post-test and 4-week follow-up.

Variables	Pre-test[a]	Post-test[b]	4-wk fw-up[c]	F & X^2	p multiple	p post hoc
rHR (bpm)	70.9±7.6	71.0±5.5	73.7±7.2	1.297	0.295	>0.05[a,b;a,c] >0.05[b,c]
6MWD (m)	520±30	524±44	521±33	0.727	0.695	>0.05[a,b;a,c] >0.05[b,c]
HRR (bpm)	30.2±6.9	29.3±7.2	32.2±6.5	3.235	0.061	>0.05[a,b;a,c] >0.07[b,c]
Flamingo BT(score)	9.91±6.11	8.46±5.24	9.36±6.12	0.629	0.543	>0.05[a,b;a,c] >0.05[b,c]
CMJ height (cm)	17.6±2.3	18.5±3.5	19.0±4.0	1.841	0.185	>0.05[a,b;a,c] >0.05[b,c]
Quad strength (kgf)	12.9±3.2	14.0±2.2	13.0±2.0	2.794	0.085	>0.05[a,b;a,c] >0.05[b,c]
MTE (score)	58.5±12.0	58.0±13.0	62.3±14.4	7.786	**0.020***	>0.05[a,b] **<0.05[a,c;b,c]**

*: statistical significance, Bonferroni-corrected. Data are presented as mean±SD. rHR: resting heart rate, HRR: heart rate recovery, BT: balance test, CMJ: counter movement jump, Quad: quadriceps, MTE: motivation to exercise.

Repeated-measures ANOVA for Group or Interaction of Time Effects

Figure 2 presents physiological and physical parameters changes according to time and participant groups. Accordingly, time and group effects were significant in rHR and HRR, demonstrating the exercise intervention's effectiveness on differences in HR measurements between groups. In other words, rHR and HRR improved at T2 and persisted at T3 in the home-based exercise group compared with T1 (Figure 2).

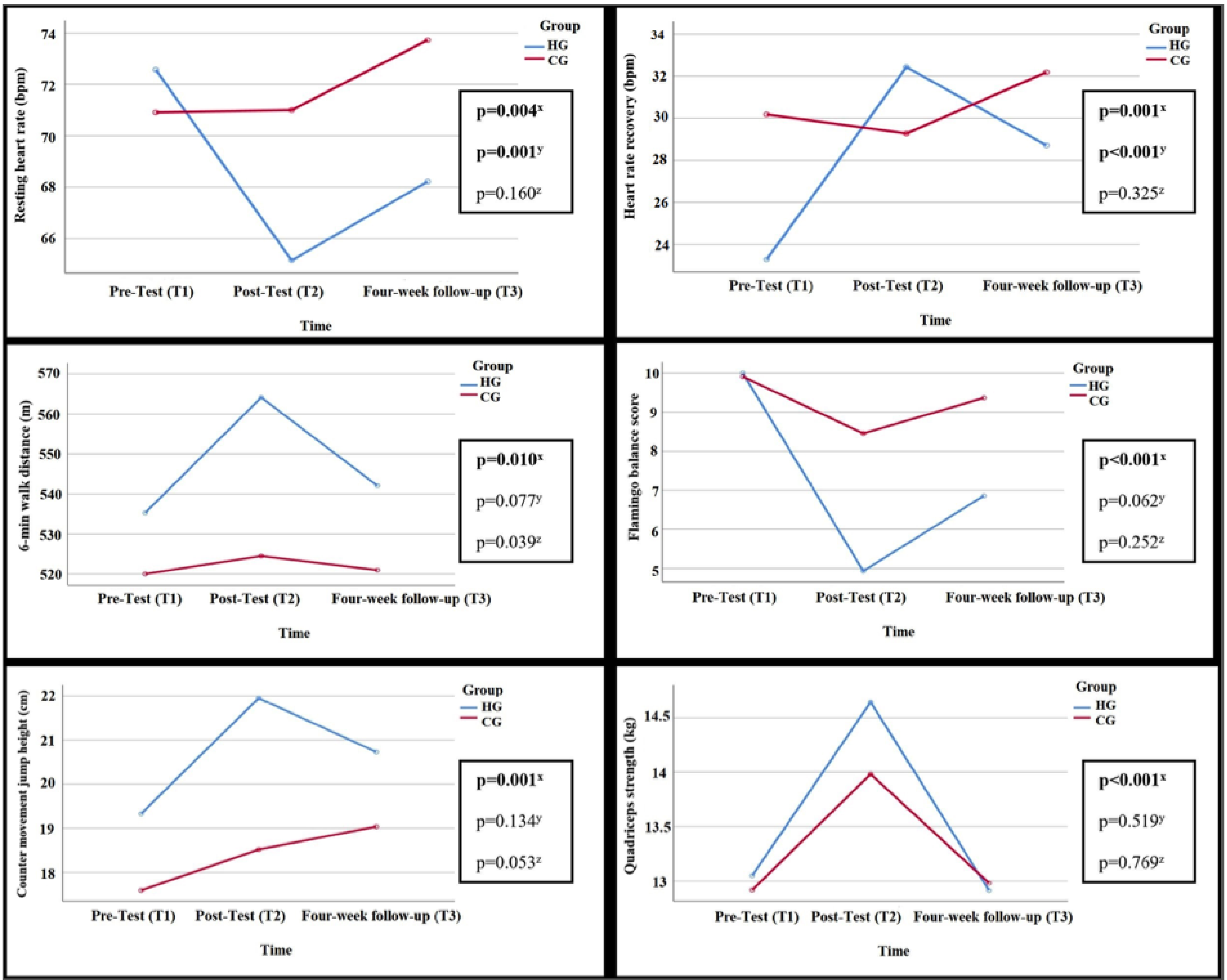

Figure 2. . Results of repeated-measures ANOVA for group or interaction of time effects. x: p-values for time, y: p values for time x group interaction effect, z: p values for group interaction.

DISCUSSION

Significant improvements in post-intervention physiological parameters, including rHR and HRR, and 6MWD, quadriceps muscle strength, jump height, and balance scores indicated an overall improvement in functional exercise capacity, endurance and strength. However, the 4-week follow-up evaluation results revealed that this improvement was not maintained for all parameters except rHR, HRR and balance scores. For the control group, the above given parameters did not change over time.

Depending on the fitness level, a significant decrease in HR is expected seconds after aerobic exercise (9), for accelerated cardiovascular recovery. Also, it has been shown that there is an increase in HRR when physiological fitness develops (23). This relationship is based on the coordinated interaction of parasympathetic reactivation and sympathetic withdrawal during recovery (10,24). In this study, exercise training positively changed walking distance, rHR and HRR values after 6MWT in the HG group. Walking distances of participants are consistent with other studies in similar populations (25). Furthermore, clinically significant increases in endurance capacity during 6MWT can be primarily attributed to increases in oxygen uptake capacity (26). It is known that physical activity interventions, especially aerobic conditioning, affect heart's autonomic regulation and improve cardiovascular risk factors (27).

After eight weeks of supervised aerobic training, cardiac recovery can be sustained after 10 months of continuous exercise training at home (28). Our findings from the 4-week follow-up emphasize that the positive effects of exercise, especially on HR parameters, continue for four weeks are simi–

lar to the long-term findings of a previous study. Thomas et al (29). reported that after 12 weeks of aerobic exercise, physiological improvements in cardiac parameters could be partially preserved even at one-year follow-up.

Similar to a study in the literature (26) that applied Zumba training to female college students, the HG group exercised at an intensity of 50-70% of the HR reserve for six weeks, three days a week, and significant improvements were observed in muscle strength, balance and jump performance, which we considered as physical fitness parameters. However, the control group had no change in physical and physiological performance. The results of the exercise and control groups may have reflected the positive effects of the intervention program in the current study in the HG group, based on studies (30) that reported that exercise was positively correlated to muscle strength and improved physical performance. A well-planned step aerobic exercise program improves aerobic capacity, lower extremity muscle strength, and static balance ability, even in the elderly (31).

Despite extensive research on fitness sensors and their applications, motivational techniques for using this technology still need to be explored (32). Often, the studies were provided with electronic HR monitors for participants' use, and program adherence was encouraged by using weekly phone calls and exercise diaries (33). In our study, the visual feedback and signs presented as innovations by the smart step board may have helped increase their exercise motivation by directing the users according to the HR variable. Also, the CG group displayed significant time-dependent differences in exercise motivation. It is possible for students' motivation to be affected by many factors (seasonal transitions, emotional state, etc.).

The small and one-sided sample size is a limitation of the study. Also, the physical activity status of participants before the intervention could have been evaluated in detail. The lack of IPAQ short form or other objective measurements to evaluate the sedentary behaviours of the participants led to a limitation regarding the physical activity levels of the groups. Additional studies are needed to interpret individuals' feedback better using the smart step board. However, the results of this study will contribute to research on the preparation of new exercise prescriptions that allow monitoring of technical modifications of the devices (step board) used while exercising, and the smartphone application. In addition, the fact that young female adults are more interested in step aerobic exercises than men, suggests that our results are also crucial from a socio-psychological point of view, as in previous study (26).

In addition to all of these, the smart step board used in this study can increase exercise participation practically and pragmatically. It can provide new exercise environments that will help us understand by changing the unhealthy living behaviours of individuals. It stands out as a design that benefits users looking for safe and supervised exercise coaching to conduct exercises at home, to improve physical and physiological fitness.

To conclude; a six-week home-based step aerobic exercise intervention can improve physical and physiological conditioning capacity in sedentary university students. Future studies may be conducted on different exercise interventions and populations. It can also randomize participants by physical activity level.

Ethics Committee Approval / Etik Komite Onayı

Afyonkarahisar Health Sciences University, Faculty of Medicine Clinical Research Ethics Committee (approval number: 2021/10/9, date: 03.09.2021)

Conflict of Interest / Çıkar Çatışması

The authors declared no conflicts of interest with respect to authorship and/or publication of the article.

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Author Contributions / Yazar Katkıları

Concept: YEK; Design: YEK, GT, ETH; Supervision: MK; Materials: YEK, GT, ETH; Data Collection and Processing: YEK, GT, ETH; Analysis and Interpretation: YEK, ETH; Literature Review: YEK, GT, ETH; Writing Manuscript: YEK, GT, ETH; Critical Reviews: MK

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