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Kertas Asli/*Original Articles*

Effects of 6-week Circuit Training on Anaerobic Performance and Simple Reaction Time in Individuals with Intellectual Disability (ID) in Kelantan State

(Kesan Latihan Litar Selama 6 Minggu Terhadap Prestasi Anaerobik dan Tindak Balas Masa Ringkas dalam Individu Kurang Daya Intektual (ID) di Negeri Kelantan)

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ABSTRACT

Participation in exercise benefits health and fitness among Intellectual Disability (ID) individuals. Circuit training is one of the exercise programme that can be tailored by manipulating the intensity, time and types of exercise. The purpose of the present study is to examine the effects of six weeks of circuit training on anaerobic fitness and simple reaction time in ID individuals. Thirty participants with mild to moderate ID were selected from individuals who are registered with the Pusat Pemulihan dalam Komuniti (PDK) and Yayasan Orang Kurang Upaya (YOKUK) in the Kelantan state. Participants were randomly divided into Circuit Training and Control groups. Participants in Circuit Training group followed a circuit training exercise programme, two times per week for six weeks, whereas participants in Control group were not involved in circuit training and carried out their regular activities. The anaerobic peak power was significantly decreased ($p < 0.001$) in Control group after six weeks. The anaerobic power of post-test was significantly improved ($p = 0.042$) from the pre-test in Circuit Training group and it was also significantly higher ($p = 0.001$) than Control group. There were no significant differences for the anaerobic capacity and simple reaction time between and within groups. Circuit training can be conducted to enhance anaerobic power in ID individuals, however longer participation may be needed to improve anaerobic capacity and simple reaction time.

Keywords: Anaerobic performance; Circuit training; Reaction time

ABSTRAK

Penglibatan dalam senaman memberi faedah kepada kesihatan dan kecergasan individu kurang upaya intelektual (ID). Latihan litar adalah program senaman yang boleh dianjurkan dengan memanipulasikan intensiti, masa dan jenis-jenis senaman. Kajian ini bertujuan menilai kesan latihan litar selama enam minggu ke atas kecergasan anaerobik dan tindak balas masa dalam individu kurang upaya intelektual (ID). Tiga puluh peserta ID tahap rendah dan sederhana telah dipilih dalam kalangan individu yang berdaftar dengan Pusat Pemulihan Dalam Komuniti (PDK) dan Yayasan Orang Kurang Upaya (YOKUK) di negeri Kelantan. Peserta dibahagikan secara rawak kepada kumpulan Latihan Litar dan kumpulan Kawalan. Peserta dalam kumpulan Latihan Litar mengikuti latihan litar dua kali seminggu selama enam minggu, manakala peserta dalam kumpulan Kawalan tidak terlibat dalam latihan litar dan meneruskan aktiviti kebiasaan mereka. Kuasa anaerobik puncak menurun secara signifikan ($p < 0.001$) untuk kumpulan Kawalan selepas enam minggu. Kuasa anaerobik ujian pasca bagi Kumpulan Latihan Litar meningkat secara signifikan ($p = 0.042$) berbanding ujian pra dan ia juga lebih tinggi secara signifikan ($p = 0.001$) berbanding kumpulan Kawalan. Tiada perbezaan yang signifikan untuk kapasiti anaerobik dan tindakbalas masa ringkas di antara kumpulan dan di dalam kumpulan. Latihan litar boleh dilaksanakan untuk meningkatkan kuasa anaerobik dalam individu ID, namun penyertaan yang lebih lama mungkin diperlukan untuk meningkatkan kapasiti anaerobik dan tindak balas masa.

Kata kunci: Latihan litar; Prestasi anaerobik; Tindak balas masa

INTRODUCTION

Participation in disabled sports events, such as the Paralympic and Special Olympics provides opportunities for individuals with intellectual disabilities (ID) to show their talents and skills in sports (Omar-Fauzee et al. 2010). To excel in sports, ID individuals should be exposed to structural physical training methods that incorporate multi-fitness components, which can help them to improve their sports-related fitness (Calders et al. 2011; Pestana et al. 2018). As far as it is concerned, there are lacked of opportunities to engage in physical fitness training among ID individuals, especially those who are at a grass-root level, but have the potential to excel in sports. In addition, the right and specific physical training need to be tailored to ID individuals, so that the training suits to their characteristics and the coaches or instructors can modify the training programme according to the performance progression (Tamin et al. 2015; Boer et al. 2014). Moreover, the methods of training may influence the responses from ID individuals. For example, Calders et al. (2011) found that a combination of aerobic and strength exercise improved the total cholesterol, muscle strength, and blood pressure in ID individuals as compared to endurance training only and no training. With regards to cognitive performance, training at a certain intensity can enhance information processing, such as reaction time that is vital for athletes to execute cognitive tasks and adapt to the changes in the game environment (Affes et al. 2021). Yildrim et al. (2001) found that participation in exercise produced a shorter reaction time as compared to the sedentary participants.

Literature shows that the positive effects from physical activity participation among ID people can be diverse, including improvements of health and physical fitness (Boer et al. 2014; Carmeli et al. 2009; Son et al. 2016; Tamse et al. 2010) and psycho-social factors (Jo et al. 2017; Bartlo & Klein 2011). Also, studies supported the role of sports and exercise to reduce the risks of chronic diseases such as high total cholesterol and high blood sugar (Calders et al. 2011), which are often caused by factors including sedentary behaviour and poor eating habit (Draheim 2006; Chow et al. 2018). In terms of health-related fitness, anaerobic fitness is one of the components that signifies the cardiovascular fitness of an individual. Anaerobic fitness can be referred to as the ability of individuals to perform an intense physical activities without depending on oxygen, but fuelled by the energy sources within the contracting muscles (ACSM 2013). Boutcher (2011) suggested that participating in a cardiovascular exercise that include high-intensity activity has an advantage in promoting anaerobic fitness, yet it is more economical and effective for weight reduction. Karner-Rezek et al. (2013) found that combining physical activities such as endurance and anaerobic sports activities improved the mean power of the anaerobic parameters.

Circuit training is an exercise that involves physical workouts through the implementation of various cardiovascular and strength exercises performed with a short rest period between them (McArdle et al. 2001). The circuit training shortens the time to perform the training, but it still allows an adequate training volume to be performed (Alcaraz Ramón et al. 2008). Intervention using circuit training has been done in both sports and exercise activities to improve health and skill-related fitness. For example, Kaikkonen et al. (2000) reported that practising circuit training that includes various exercises with a short rest interval between sets improved muscular endurance and running distance in untrained participants. Sonchan et al. (2017) found that involvement in the eight weeks of circuit training significantly increased anaerobic capacity, muscle strength, and cardiovascular endurance in however, the similar changes did not occur in the Control group. Within the group of ID athletes, circuit training has significantly increased the aerobic cardiovascular fitness (VO2 max), which was measured using the Queen's College Step Test and leg muscle strength test (Sumaryanti et al. 2019). Nevertheless, studies that apply circuit training are seldom conducted in ID individuals as compared to normal individuals. Interestingly, it is acknowledged that the circuit training does not only give positive effects to physical fitness, but it is also enjoyable, thus, it may enhance individuals' motivation and interest to do exercise (Wilke et al. 2019). Moreover, circuit training can be adopted as an essential part of physical training, rather than assigning similar training programme that might lead to boredom.

The main purpose of this study is to investigate the effects of a circuit training programme among ID individuals. The training programme was conducted for six weeks consisted of different exercise movements that were designed by considering the participants' fitness levels. It was expected that after completing the six weeks of the circuit training programme, participants would show improvement in terms of anaerobic fitness components and reaction time. The highlight of this study is not only to determine participants' physical quality, in fact it may also enrich their health and well-being.

MATERIALS AND METHODS

STUDY DESIGN

This study used a randomised controlled trial, pre-test and post-test study design. Using a block randomisation, researchers randomly assigned the participants into two groups; Circuit Training group and Control group. The groups were equally distributed based on age, gender, body mass index (BMI), and intellectual level of the participants. During the six weeks intervention, participants in the Circuit Training group followed a circuit training programme as designed in Table 1.

ETHICAL APPROVAL

The approval to conduct the study was obtained from the Universiti Sains Malaysia (USM) Research Ethics Committee (USM/JEPeM/19020127).

PARTICIPANTS

Thirty healthy male and female ID individuals (19 slow learners, 8 Dyslexia, 2 mild Autism, and 1 mild Syndrome Down) from the Pusat Pemulihan dalam Komuniti (PDK) and Yayasan Orang Kurang Upaya (YOKUK), Kelantan participated in this study voluntarily. The mean age of the participants was 22.4 with a standard deviation of 3.4. Participants were able to understand and communicate in Malay language, free from any physical injuries and diseases, and able to perform physical movements. In the beginning, researchers explained to participants regarding the study procedures with the help from their teachers. Also, participants were reminded that they are free to withdraw from the study anytime if they experience pain, discomfort or do not want to continue after or during the training sessions. Participants returned the consent forms that were signed by themselves, parents and teachers as an agreement to participate in the study.

MEASURES

ANTHROPOMETIC MEASURES, RESTING HEART RATE AND RESTING BLOOD PRESSURE

The participants' baseline including anthropometric measurements (height and body weight), body composition, resting heart rate, and resting blood pressure were measured before the intervention started. Height (cm) was measured using a stadiometer. Body weight (kg), body mass index (BMI; kg.m-2), body fat percentage (%), and fat-free mass (kg) were measured using TANITA bioimpedance analysis machine. Resting heart rate (bpm) and resting blood pressure (mmHg) were measured using an OMRON automated blood pressure machine.

ANAEROBIC PERFORMANCE

A Wingate anaerobic test (WAnT) was used to estimate the power and capacity of the anaerobic energy system. The WAnT requires participants to pedal as fast as they can at a resistance that is set based on the body mass (0.075 kg per kg body weight) for 30 seconds. A Wingate cycle ergometer was used for the WAnT and it was interfaced with a computer that displays results of anaerobic power (i.e., the amount of power that is sustained throughout the test), anaerobic capacity (i.e., total work completed during the test), and anaerobic peak power (i.e., the highest amount of power generated during the test). Anaerobic power is determined based on the maximum number of revolutions in five seconds. Anaerobic capacity is determined based on the total revolutions throughout the 30-sec test. Anaerobic peak power is determined based on the decrement in power output throughout the test (Bushman et al., 2006). Chia et al. (2002) reported a high reliability of mean power (0.97) and peak power (0.90) of WAnT when the WaNT is conducted among ID participants.

SIMPLE REACTION TIME

The simple reaction time indicates how fast individuals react to a given stimulus (one stimuli-one response). In this study, a reaction time test available in the Psytoolkit website, https://www.psytoolkit.org/lessons/experiment_simple_choice_rts.html (Stoet 2017) was used. According to Kim et al. (2019), the test is viable to examine the simple reaction time. During the simple reaction time test, participants pressed a space bar on a keyboard at the time the symbol 'X' appeared on the laptop screen, as quickly as possible. Participants completed three attempts and the researcher recorded the average time in the unit milliseconds.

STUDY PROCEDURE

All participants came to the pre-test and post-test sessions that were conducted in the USM Sports Complex. During the pre-test, first, the researcher assessed the anthropometric measures and health profiles of participants. Then, the researcher conducted an assessment for their fitness capacity using the WAnT, followed by a reaction time test after taking a short rest. After completing all tests, the researcher invited only participants in Circuit Training group to come to Sports Complex 2 in the following week to perform their circuit training.

The circuit training programme consisted of 20 to 30 minutes of exercises along with an exercise instructor, which was conducted two times per week (on non-consecutive days) for six weeks. First, participants started with a warming up (stretching and slow jog) for five minutes. Next, participants continued the circuit training that was designed by the researcher. The circuit training consisted of different types of aerobic and resistance exercises, across six stations as shown in Table 1. During the exercise sessions in Week 1 and Week 2, participants performed as many repetitions as possible within 20 seconds, with 10 seconds of passive rest between each station. After completing the exercise in one station, participants moved to the next stations until they completed all six stations. This was considered as one set. After about 60 seconds of passive rest, participants performed the exercise and completed the second set. Participants ended the circuit training with a cooling down session for 10 minutes.

After completing Week 2, participants continued the exercise intervention until Week 6. The number of sets was similar for each week and the time duration in each station was increased gradually in every two weeks, with 10 seconds of rest between each station. This was done by considering the principle of exercise progression (i.e., increasing the duration as the body adapts to a given activity pattern). During the circuit training, researcher monitored the participants' heart rate (HR) using the HR monitor, to ensure that they exercised within an intensity range of 40 - 60% Heart Rate Reserve (HRR) or within the average range HR of 145 to 162 beats per minute (bpm).

After completing six weeks of circuit training programme, researcher invited the participants in Circuit Training and Control groups to attend the post-test session. Participants performed tests that were similar to the tests being conducted in the pre-test. The flow chart for the study procedure is presented in Figure 1.

TABLE 1 Circuit training programme

Week	Time/ station (secs)	No. of set	Rest between station (seconds)	Intensity (Moderate to Hard)	Stations (in order)
1 and 2	20	2	10	40 – 60% HRR	Station 1: High knee Station 2: Push-up Station 3: Back kicks Station 4: Sit up Station 5: Tuck jump Station 6: Squat
3 and 4	30	2	10	40 – 60% HRR	Station 1: High knee Station 2: Wall push-up Station 3: Tuck jump Station 4: High plank Station 5: Squat Station 6: Back kicks
5 and 6	40	2	10	40 – 60% HRR	Station 1: Jumping jacks Station 2: Calf raise Station 3: High plank Station 4: Squat Station 5: Punch Station 6: High kicks

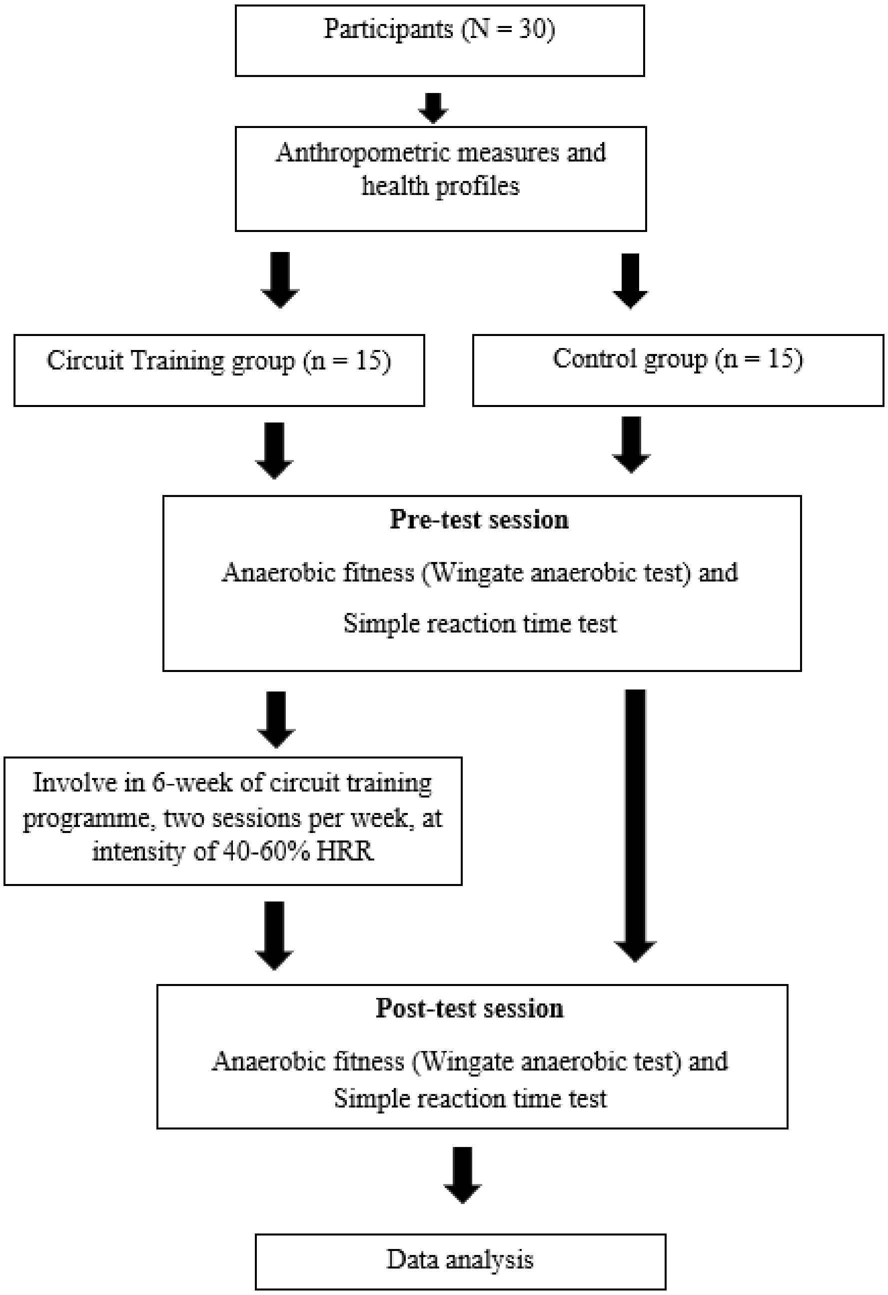

FIGURE 1 Flow chart of study procedure

STATISTICAL ANALYSIS

IBM Statistical Package for Social Sciences (SPSS) Version 24.0 was used for the statistical analyses. The normality of the distribution of the data was assessed using the Shapiro-Wilk test. Descriptive analysis was performed on the anthropometric characteristics of the participants. The two-way mixed ANOVA was performed for all measures. All data were reported as means and standard deviations for both groups.

RESULTS

ANTHROPOMETRIC MESUREMENT, BODY COMPOSITION, RESTING HEART RATE AND RESTING BLOOD PRESSURE

Table 2 shows the mean age and participants' baseline of body weight, body height, BMI, body fat percentage, fat-free mass (FFM), resting heart rate, and resting blood pressure at the beginning of the study for Circuit Training and Control groups. There were no significant differences for all anthropometric characteristics between the Circuit Training and Control groups.

TABLE 2 Anthropometric mesurement, body composition, resting heart rate and resting blood pressure of participants in Control group and Exercise group

	Control group		Exercise group		
Variables	n	Mean ± SD	n	Mean ± SD	p-value
Age (year)	15	21.4 ± 2.5	15	23.3 ± 4.3	0.140
Body weight (kg)	15	52.7 ± 10.6	15	53.4 ± 9.8	0.985
Body height (cm)	15	154.6 ± 9.3	15	156.4 ± 7.1	0.516
BMI (kg.m-2)	15	22.1 ± 4.2	15	22.6 ± 4.6	0.384
Body fat (%)	15	31.7 ± 12.2	15	27.0 ± 10.3	0.650
Fat-free mass (kg)	15	35.1 ± 5.8	15	38.5 ± 6.2	0.668
Resting SBP (mmHg)	15	120.4 ± 10.1	15	112.5 ± 15.2	0.199
Resting DBP (mmHg)	15	73.9 ± 6.6	15	66.7 ± 8.4	0.178
Resting HR (bpm)	15	83.3 ± 10.3	15	83.0 ± 12.2	0.525

ANAEROBIC PEAK POWER, ANAEROBIC POWER, ANAEROBIC CAPACITY AND SIMPLE REACTION TIME

Table 3 shows the results of anaerobic peak power, anaerobic power, anaerobic capacity and simple reaction time in the pre- and post- test between Circuit Training and Control groups.

The anaerobic peak power was significantly decreased from the pre-test to post-test in Control group ($p < 0.001$). The mean anaerobic peak power was decreased from the pre-test to post-test in both groups.

The anaerobic power was significantly increased ($p = 0.042$) from the pre-test to post-test in Circuit Training group. Also, the anaerobic power was significantly higher ($p = 0.001$) in Circuit Training group than Control group at post-test. The mean anaerobic power was increased from pre- to post-test in both groups.

There were no significant differences in anaerobic capacity between and within Circuit Training and Control groups. The mean anaerobic capacity was increased from pre- to post-test in Circuit Training group, however it was decreased in the Control group.

There were no significant differences in simple reaction time between and within Circuit Training and Control groups. The mean simple reaction time was decreased from pre- to post-test in Circuit Training group, however, it was increased in Control group.

TABLE 3. Pre-test and post-test data of anaerobic peak power, anaerobic power, anaerobic capacity and simple reaction time in Circuit Training group and Control group

Measures	Group		
	Circuit Training (n = 15)	Control (n = 15)	Mean difference (group)
Anaerobic peak power (Watt)			
Pre-test	363.0 ± 138.3	448.0 ± 129.8	85.0 ± 48.9
Post-test	361.0 ± 156.1	328.0 ± 82.7	33.0 ± 45.6
Mean difference (pre-post test)	-2.0 ± 53.9	-120.0 ± 39.7[a]	
Anaerobic power (Watt)			
Pre-test	6.3 ± 1.8	6.5 ± 2.7	0.3 ± 0.8
Post-test	9.1 ± 3.4	6.9 ± 2.8	2.2 ± 1.1[b]
Mean difference (pre-post test)	2.8 ± 1.0[a]	0.4 ± 1.0	
Anaerobic capacity (Watt)			
Pre-test	4.2 ± 2.2	3.8 ± 1.9	0.4 ± 0.8
Post-test	4.3 ± 2.0	3.4 ± 1.5	0.9 ± 0.6
Mean difference (pre-post test)	0.1 ± 0.8	-0.4 ± 0.6	

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Simple reaction time *(milisec)*			79.0 ± 99.7
Pre-test	509.0 ± 193.0	588.0 ± 334.4	245.0 ± 124
Post-test	492.0 ± 194.5	737.0 ± 439.3	
Mean difference (pre-post test)	-17.0 ± 70.7	149.0 ± 142.6	

[a] $p < 0.05$, significant difference within group
[b] $p < 0.05$, significant difference between groups at post-test

DISCUSSION

The present study focuses on the anaerobic performance and reaction time among ID individuals of PDK. Most participants in this study were non-athletes and they did not engage in regular exercise activities. The anthropometric characteristics suggest that the participants had a normal BMI, an acceptable body fat percentage and a good health status, hence, engaging them in physical activities is beneficial for their health and fitness.

With regards to the anaerobic performance, based on the data of mean difference, it can be considered that there were no prominent changes had occurred in the anaerobic peak power and anaerobic capacity after participants completed six weeks of circuit training programme. This is probably because the circuit training was only performed at moderate intensity, thus it did not stress the participants much and did not activate the anaerobic system that could lead to the lactate production. Physical training that involves high-intensity levels, for example, high intensity interval training (HIIT) has been shown to improve the anaerobic performance for the reason that the type of training promotes glycolytic activity (Jabbour et al. 2015). Another concern is that when the anaerobic fitness is measured in untrained ID individuals, they are likely less consistent in their power performance compared to trained individuals with ID (Chia et al. 2009), which was also discovered in the present study. In addition, it was speculated that ID individuals possess different muscle-fibre characteristics and a reduced motor-unit activation, however, Chia et al. recommended further research on these aspects. Performing circuit training in the present study were mostly depending on the participants' efforts to push themselves to perform as many repetitions as they can within the given time duration.

Moreover, the circuit training performed in the present study did not involve high resistance as much as in the training when the specific load or training equipment is used. In general, previous studies suggested performing strengthening exercise, whether it is performed alone or when it is combined with aerobic exercises, produced positive results on individuals' power. For example, a strengthening exercise at a specified strength intensity ranging from 20 to 10 Repetition Maximum (RM) has been shown to improve the muscle strength of ID individuals (Calders et al. 2011). Similarly, Wu et al. (2017) found that the explosive power, which also reflects the anaerobic fitness, was found to be significantly improved in ID participants underwent circuit training, however, the intervention sessions conducted by Wu et al. involved a higher frequency and number of weeks as compared to the present study. It is worth to note that when executing movements such as squat, there were times when participants did not exert their effort much to remain at the prescribed exercise intensity. Although the participants' physical characteristics and anthropometric profiles were considered good, performing circuit training might be challenging for them considering they were physically untrained individuals. Overall, the present study implies that the circuit training produced positive effects in the anaerobic fitness although some results were not significant. In contrast, anaerobic fitness was declined in participants who did not involve in circuit training.

The anaerobic power increased after participating in six weeks of circuit training, however, the result for the anaerobic peak power did not occur as expected. The anaerobic peak power declined from pre- to post-test in both groups, with only a small difference was found in Circuit Training group (-2 Watts) as compared to Control group (-120 Watts). However, a large difference observed within the Control group could be due to the data that is not equivalent at pre-test, although randomisation has been performed when assigning the participants for each group. With regards to the training aspect, participants performed repetitive movements involving leg muscles (e.g., squat, back kick, jumping jack), thus, the training would improve the muscular power and give a advantage for participants to push their legs against high mechanical power in the first five seconds of WAnT. Jabbour et al. (2015) reported that all the anaerobic system contributions (e.g., peak power, power output) increased and correlated each other after participants cycled at supramaximal exercise for six weeks. In the present study, although the intervention duration was similar to a study by Jabbour et al., the circuit training programme was conducted at a moderate intensity level, thus, it might not enough to enhance the ATP-PC metabolic system required for a powerful cycling against the resistance. Moreover, the WAnT protocol is vigorous and participants must tolerate with a high mechanical force and a feeling of discomfort throughout the test. Hence, giving verbal encouragement from the start to the end of the WAnT test is important for participants to deliver their maximal efforts.

Nonetheless, the result of the anaerobic power was in line with a study conducted by Sonchan et al. (2017) among ID individuals, in which the anaerobic power of the experimental group was significantly higher in the circuit training group (8.31 Watts) than the control group (6.95 Watts). In contrast to the present study, Sonchan et al. measured the muscle strength, in which they claimed that increased anaerobic power was associated with the improvement of muscle strength. Participants in the present study attended two times per week for six weeks of circuit training, whereas in the Sonchan et al. study, participants attended three times per week for eight weeks of circuit training. Accordingly, a higher frequency of circuit training per week and longer duration of intervention may enhance the anaerobic fitness among untrained individuals as being proposed by Taskin (2009).

With regards to simple reaction time, although the results were not significant, the present study showed that participating in circuit training facilitated a faster reaction time, as opposed to participants who did not exercise. Also, participants in the Circuit Training group had a lower simple reaction time than participants in the Control group in the pre-test and post-test. The result was consistent with the previous study by Yildirim et al. (2010), in which the reaction time for the circuit training group reduced after 12 weeks of physical fitness training as compared to the control group. It is possible that the improvement in the reaction time ocured because the exercises were performed in a quick movements and involved exercise changes, in which it had triggered participants' psychomotor stimuli, leading to a better reaction time. Poels et al. (2008) indicated that physical activity promotes the sympathetic system activation that induces more blood flow, allowing the brain to have a better cognitive processing. Finding in the present study is also in line with a study by Chen (2013) who reported that participants who performed 20 minutes of aerobic exercise on a treadmill demonstrated a faster reaction time than the control group. Also, Aouadi et al. (2015) demonstrated that the aerobic exercise training group displayed significantly faster reaction time ($p < 0.01$) as compared to the group that was not prescribed to any exercise. This suggests exercise as an effective method to improve the cognitive function of mentally retarded individuals.

CONCLUSION

In conclusion, performing six weeks of circuit training in the present study showed a significant improvement on anaerobic power. Longer participation may be needed to improve anaerobic capacity and simple reaction time. The present study highlights the implementation of circuit training with the aim to build physical fitness in ID individuals. In spite of the participants in this study were mentally challenged, they had demonstrated remarkable abilities to perform the circuit training. It is further suggested that, when implementing a circuit training to ID individuals, a monitoring from instructors, teachers, or families is important to ensure they can exert maximal effort as well as to support them to finish the training. The improvement of physical fitness can certainly influence their ability to perform daily tasks, which will promote a better lifestyle for health and wellness.

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