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VIRTUAL-BASED AQUATIC PLYOMETRIC TRAINING: HOW IT IMPACTS LOWER EXTREMITY MUSCLE STRENGTH?

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Abstract The low achievement of long jump athletes and the limited virtual-based aquatic plyometric exercises to increase lower extremity muscle strength are the gaps in this study. This study aims to increase lower extremity muscle strength of long jump athletes through virtual-based plyometric aquatic training. This research adopted a mixed methods research. This study involved participants from long jump athletes at the University of Tanjung Pura in Indonesia (n = 20). Participants were divided into two groups, namely an experimental group (n = 10) and control group (n = 10). The quantitative instrument involved a leg dynamometer for measuring lower extremity muscle strength. While, the qualitative instrument used in-depth interview. Quantitative data analysis was carried out through IBM SPSS to calculate descriptive statistics and normality, while the paired sample t-test to test differences in lower extremity muscle strength values in the experimental and control groups. Qualitative analysis was carried out through recording, describing and coding stages, which categorized into three themes. Based on quantitative results, it showed that virtual-based plyometric aquatic training was proven significantly increase lower extremity muscle strength ($p \leq 0.05$), but there was no significant effect in the control group ($p \geq 0.05$). Qualitative results found out that most of the participants gave a positive opinion regarding virtual-based plyometric aquatics. Thus, this study confirms that virtual-based plyometric aquatic training can be used to increase lower extremity muscle strength.

Key words: virtual-based plyometric aquatic, lower extremity, muscle strength, mixed methods research

Introduction

Cases of COVID-19 were first reported in Wuhan city, China (González et al., 2021) and had negatively affected to several sectors, including business, tourism, sports activities in elementary, middle and high schools until universities at the national (Juliantine & Setiawan, 2022) and internationally level (Grix et al., 2021; Marshall et al., 2022). At the end of 2022, this condition was recovered and transmission rates decreased in several countries. However, the consequence that need to be resolved was the difficulties in carrying out training because the physical condition of athletes was decline significantly (Gani et al., 2022), one of which related to lower extremity muscle strength in long jump athletes.

Long jump is track and field athletic event that need an athlete to jump as far as possible. The long jump consists of 4 phases namely run, take off, flight and landing. According to Taher et al. (2021) to obtain a good long jump performance, it was depended on horizontal speed, take-off technique and landing on the sand. A study reports that long jump performance is highly correlated with lower extremity muscle strength (Zhou et al., 2020). Lower extremity muscle strength is an important component for athletes in several types of sports (de Villarreal, Requena & Newton, 2010) for example in soccer, large muscle strength can generate hard kicks (Zghal et al., 2019) and in sports swimming, large lower extremity muscle strength could accelerate the speed (Gani et al., 2022). In addition, lower muscle strength has an important role to produce hard kicks in karate (Ioannides et al., 2020). Meanwhile, in long jump, lower extremity muscle strength resulted in long take-offs (Ren et al., 2022). Therefore, proper training was needed to increase lower extremity muscle strength during the COVID-19 pandemic crisis through virtual-based plyometric aquatic training.

Plyometric training is a type of muscle strength training that has been widely used in team and individual sports. Plyometric training has movement characteristics involving eccentric phases, isometric phases and concentric phases (Ramírez et al., 2022). According to Arazi, Mohammadi & Asadi, (2014), plyometrics is an exercise that consists of jumping, bounding or hopping. In addition, this training can be conducted on land such as sand, grassy ground or water (Chomani et al., 2021; Biswas & Ghosh, 2022; Biswas & Ghosh, 2022b). Virtual-based plyometric aquatic training was carried out virtually in water. Previous studies had documented the benefits of plyometric training, for example the effectivity in increasing muscular power and speed (Ameer, 2020), leg mobility, joint stability and leg muscle strength (Chomani et al., 2021) and motor performance skills (Peitz, Behringer & Granacher, 2018). A recent study reported evidence that plyometric training for 6 weeks was effective in increasing several components such as power, muscle strength, and rate of force development (Ioannides et al., 2020).

There were various research on plyometric training that had been documented internationally (Behm et al., 2017; However, there was no previous research that reported about the effect of virtual-based plyometric aquatic training in increasing lower extremity muscle strength in long jump athletes. In addition, this study tries to present a novelty, which is to analyze the effect of virtual-based plyometric aquatic training through a mixed methods research. It is expected that this research could contribute to the development of virtual based plyometric training methods or involved technology application, so that trainers can use this training during the COVID-19 crisis. Therefore, the purpose of this study was to analyze the effect of virtual-based plyometric aquatic training to increase lower extremity muscle strength.

Methods

The researcher had asked for permission from the Tanjung Pura University Committee with number: 230/UTP/10/2022 before started this study. In addition, this research was conducted based on the guidelines of the World Medical Association Code of Ethics (Declaration of Helsinki for Humans). This study adapted the mixed methods research type, namely a combination of quantitative and qualitative research. An explanatory sequential design was conducted in two stages, the first stage was carrying out research and collecting quantitative data, then the second stage was conducting research and collecting qualitative data (Gani et al., 2022). The detail of mixed methods design is presented in Figure 1.

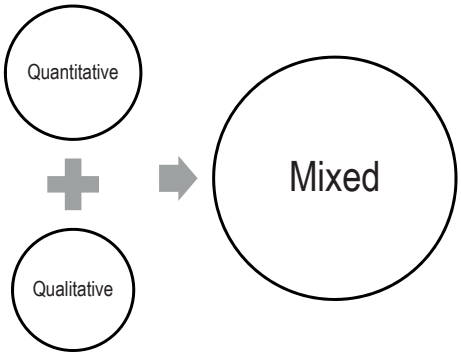

Figure 1. Mixed methods research design

Participants

All participants were long jump athletes from Tanjungpura University in Indonesia (n = 20). All participants agreed to be involved and had signed thee written informed consent before the experiment started. The participants were selected through random sampling by sending emails to 30 athletes and only 20 athletes responded and willing to be involved. Participants were randomly divided into two groups, the experimental group that received the aquatic virtual plyometric training program consisted of 5 males and 5 females (age: 21.05 ±2.3 year, weight: 55.68 ±6.4 kg, height: 1.62 ±0.5 cm) and the control group consisted of 5 males and 5 females (age: 20.47 ±0.9 year, weight: 50.65 ±7.8 kg, height: 1.60 ±0.4 cm). The inclusion criteria for participants included: the profile of participants in participating plyometric training, physically active, healthy and must be free of musculoskeletal injuries in the past year. Before the research started, all participants were given information about the rules of this research. Then, they were required to create and sign a statement about their willingness to participate this research. Participants involved in this study were given a reward of 20 USD to appreciate their involvement.

Instruments

Quantitative Instruments

A quantitative instrument was used to measure lower extremity muscle strength using a leg dynamometer (Cha & Lee, 2022). This test was carried out through squats, with 90° knee flexion and the measurement were repeated 2 times with an interval of 2 minutes. The highest leg muscle strength score was taken to analyze.

Qualitative Instruments

A qualitative instrument was used to investigate the effect of a virtual-based plyometric aquatic training program through in-depth interviews for 30 minutes per individual. The interview was intended for athletes in the experimental group only, to obtain their opinion about the effects of using virtual-based plyometric training. This instrument has proven to be effective based on the previous studies results (Gani et al., 2022; Juliantine & Setiawan, 2022).

Research procedure

This research was conducted from October to November 2022 at Tanjung Pura University in Indonesia. The quantitative research was conducted in thirteen meetings, at the first meeting (1 October, 2022), all participants carried out an initial test (leg dynamometer test). Then, participants carried out a virtual-based plyometric training program from the second meeting (4 October 2022) until the 12th meeting (29 October 2022). After that, in the last meeting (8 November 2022) all participants carried out the final test, which was in the form of a leg dynamometer test.

Whereas the qualitative research was carried out on 10 and 12 November 2022, all participants in the experimental group were interviewed about their experiences when participating in virtual-based plyometric aquatic training. In one day the researchere interviewed 5 participants.

Virtual-based plyometric aquatic training Program

The participants carried out 12 virtual-based plyometric aquatic training sessions in 3 times a week, namely on Tuesday, Thursday and Saturday. Before the training started, the participants watched aquatic plyometric exercises for 10 minutes on virtual reality (Figure 2), then carried out a dynamic warm-up for 5 minutes, such as jogging and stretching the calves, hamstrings, quadriceps. Each set of plyometric aquatic exercises took 10–15 minutes to complete and 2 minutes break before continued to the next set. Finally, cool-down activities was conducted for 5 minutes. The virtual-based plyometric training program is presented in Table 1.

Figure 2. Virtual-based plyometric training
Source: Author's own.

Table 1. Virtual-based plyometric training program

Week	Repetition	Sets	Activities
1	2	3	Tuck Jump
2	3	3	Squat Jumps
3	4	3	Lunges
4	3	3	Jooging
5	5	3	Kick front

Control group program

In contrast, the control group performed regular daily exercises, including stair climbing, side lunges, and split squats. The control group participants were subjected to monitoring procedures to ensure their presence did not influence the study outcomes.

Statistic analysis

Quantitative analysis

All data from the quantitative research results were analyzed via IBM SPSS 25.0 (Armonk, NY: IBM Corp). The analysis was conducted in following steps. First, determining the statistical descriptive values (mean and standard deviation), data normality (Shapiro-Wilk). Second, the Paired sample t-test was used to test differences in lower extremity muscle strength values in the pretest and posttest in the experimental and control groups (Juliantine & Setiawan, 2022). The significance level was 0.05.

Qualitative analysis

Data from in-depth interviews were analyzed through qualitative thematics, through 4 stages, including: recorded, described, coded and categorized into three themes (Gani et al., 2022) details of each theme are as follows:

Theme 1: Advantages of virtual-based plyometric aquatic training.

Theme 2: Difficulties of virtual based plyometric aquatic training.

Theme 3: Impact of virtual based plyometric aquatic training.

Results

Quantitative results

The normality test results in this study were normally distributed (Table 2). While the descriptive statistical result is presented in Table 3. Table 4 shows that the experimental group that received virtual-based plyometric aquatic training had a significant effect on increasing lower extremity muscle strength in both men and women ($p \leq 0.05$), but there was no significant effect in the control group ($p \geq 0.05$).

Table 2. Normality test

	Gender	Shapiro-Wilk			
		Statistic	df	p	Keterangan
Experimental Group					
Pre-test	Boy	0.970	5	0.876	Normal
	Girl	0.932	5	0.607	Normal
Post-test	Boy	0.914	5	0.490	Normal
	Girl	0.854	5	0.206	Normal
Control Group					
Pre-test	Boy	0.980	5	0.937	Normal
	Girl	0.928	5	0.585	Normal
Post-test	Boy	0.935	5	0.627	Normal
	Girl	0.630	5	0.201	Normal

Table 3. Descriptive statistics

Dependent Variable	Experimental Group				Control Group			
	Boys (n = 5)		Girls (n = 5)		Boys (n = 5)		Girls (n = 5)	
	Pre M(SD)	Post M(SD)	Pre M(SD)	Post M(SD)	Pre M(SD)	Post M(SD)	Pre M(SD)	Post M(SD)
Extremity muscle strength	32.00(3.74)	45.80(1.64)	30.40(2.19)	39.90(5.26)	27.00(4.30)	31.00(3.93)	27.00(5.82)	31.80(4.60)

Table 4. Differences in pretest-posttest scores on limb muscle strength in experimental and control group

Dependent Variable	Experimental Group (n = 10)						Control Group (n = 10)					
	Pre-Post			Pre-Post			Pre-Post			Pre-Post		
	Boys	t	p	Girls	t	p	Boys	t	p	Girls	t	p
	M(SD)			M(SD)			M(SD)			M(SD)		
Extremity muscle strength	13.80(3.42)	9.021	0.001	9.40(4.82)	4.354	0.012	4.00(6.96)	1.284	0.268	4.80(9.91)	1.083	0.340

Qualitative results

The results of qualitative research through in-depth interviews are as following:

Theme 1: Experience in participating in a virtual-based plyometric training program

The first theme of this study was the experience of athletes in participating in virtual-based plyometric aquatic training. Based on these perceptions, the researcher can obtain important result. In this case the participants argued that:

"I am very lucky to be able to take part in this program, because it was very fun and we got a lot of experiences" (interviewed with participants 1, 3, 5).

"I enjoy this virtual plyometric aquatic training, because we can carry out the exercises by watching animation on virtual reality before training on water" (interviewed with participants 2, 4, 7).

This was a valuable experience for us, because we can do plyometric aquatic exercises which were carried out in a swimming pool by watching virtual reality. The plyometric training from virtual reality energized us to be excited and enthusiastic (interviewed with participants 6, 4, 9). We gained a lot of movement experience from this program, for example kick front and tuck jump exercises in water absolutely more fun than exercise on land (interviewed with participants 8, 10).

Theme 2: Advantages of virtual-based plyometric training

The advantage was the first aspect that must be clearly stated, because it has an important role to show factors that contribute to the benefit of virtual-based plyometric aquatic training. Participants argued that:

"This training has an advantage in increasing lower extremity muscle strength, because it was carried out in water. The load in water was much greater, so our muscle strength increased gradually" (interviewed with participants 3, 6, 7, 10).

"In my opinion, performed training in the water by watching plyometric movements on virtual reality has significant advantages, for example encourage our enthusiast, passion and motivation, so that it can obtained the maximum training results " (interviewed with participants 1, 2, 4).

"I can't imagine that I could perform a further leap, that was because of the impact I had on joining this program" (interviewed with participant 9).

"It can be said that this program has several advantages, such as (i) we learned plyometric exercises on virtual reality, (ii) then we did the plyometric exercises in the water and it was proven that we had much better jumping abilities than previous" (interviewed with participant 3, 5, 6, 7).

Watching plyometric movements on virtual reality, help us to understand some movements such as tuck jumps, squat jumps, lunges, jogs and front kicks that was performed in the water, so that we can perform the exercises optimally (interviewed with participant 8, 10).

Theme 3: Difficulty of virtual based plyometric training

The last theme in this study related to difficulties or obstacles in carrying out virtual-based plyometric training. In this case the participants revealed their opinion that:

> "This training cannot be done if you don't have a virtual reality, because plyometric movements are presented via virtual reality" (interviewed with participants 5, 7, 9, 10).

This virtual-based plyometric training will be less effective if it is used in large numbers of athletes, for example more than 50 people, because it is difficult to control and it will be difficult for athletes to watch plyometric movements presented on virtual reality, because it's limited (interviewed with participants 1, 2, 3, 4, 6, 8).

Discussion

The purpose of this study was to investigate the effect of virtual-based aquatic plyometric training to increase lower extremity muscle strength.

The quantitative findings in this study indicated that the virtual-based plyometric aquatic training program has positively proven to increase lower extremity muscle strength, because plyometric training in water have a bigger load. Basically, plyometrics performed in water could change the elastic ability of the muscles much better, because the lower extremity muscles could contract with more force due to water resistance and body weight. According to Biswas & Ghosh (2022b)aqua plyometric training and weighted vest aqua-plyometric training, when carrying out plyometric aquatic training, the muscle workload increased during the concentric phase so that it could increase muscle strength. This finding was in line with previous studies which reported that plyometric training can significantly increase leg muscle strength in volleyball athletes (Gjinovci et al., 2017; Dell'Antonio et. al, 2022), futsal (Zekri, Tajali & Ghotbi, 2019), football (Chomani et al., 2021), judo (Kurniawan et al., 2021). In addition, plyometric aquatic training can also increase muscle strength in basketball athletes (Asadi & Arazi, 2012). However, the opposite finding occurred in the control group, which showed no significant increase in lower extremity muscle strength.

Qualitative findings in this study showed that most of participants agreed that virtual-based plyometric aquatic training had a positive effect on the development of lower extremity muscle strength, for example tuck jumps, squat jumps, lunges, jogging and kick fronts were more fun and challenging when they carried out it in the water, because the density of water is greater. Thus, this research proved that virtual-based plyometric aquatic training was effective in increasing lower extremity muscle strength in long jump athletes (Taher et al., 2021)specific-motor and functional abilities. The aim of this study was to examine the response effect of vertical and horizontal plyometric training on explosive capacity and kinetic variables in long jump athletes. Material: The participants of this study were twenty professional jumpers.

Finally, the uniqueness and novelty found in this study is that virtual-based aquatic plyometric exercises have been shown to have a positive effect on increasing the lower extremity muscle strength of long jump athletes based on both quantitative and qualitative research.

Conclusions

Based on these results, it can be concluded that virtual-based plyometric aquatic training was effectively used to increase lower extremity muscle strength in long jump athletes. This research contributes to existing knowledge about the importance of using virtual-based plyometric aquatic training and athletes can continuously use this training to maintain and improve lower extremity muscle strength. However, several limitations need to be acknowledged, in terms of using limited number of participants and only involved long jump athletes, so it had not been proved whether this training was effective when implemented in other sports. Future research needs to be conducted by involving more participants and implementing virtual-based plyometric aquatic training in swimming, pencak silat or dominant sports that often use lower extremity muscle strength.

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