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INFLUENCE OF ISOINERTIAL EXERCISES ON LOWER LIMB POWER AND STABILITY OF VOLLEYBALL PLAYERS

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ABSTRACT. Introduction: Flywheel training devices have initially been used as means of astronaut conditioning in outer space during long missions. The system uses a rotating disc to store the energy during the concentric phase of the movement and converts it to resistance during the eccentric phase. The inertia of the flywheel offers the load of the exercise performed. Later, these devices started being used in injury rehabilitation and performance training. **Objective:** The objective of the study was to measure the effect of isoinertial exercises using a flywheel training device on lower limb power and stability. Also, we wanted to verify if a positive correlation can be found between force, power and stability. **Methods:** 15 female volleyball players were included in the study N=15. During 4 months the subjects trained twice a week using the flywheel device. Initial and final tests were performed using OptoJump, Y balance test and the device's own measuring system. The measured parameters were average power, average force, jump height and composite reach distance index. **Results:** Significant improvement have been found between the initial and final results for power, force, jump height and composite reach distance index p<.01. **Conclusions:** A flywheel isoinertial training device can be seen as a viable alternative for power and stability development for volleyball players.

Keywords: *power, stability, volleyball, isoinertial*

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Introduction

Lower limb power is very important in a sport such as volleyball. Along with strength conditioning of the players, we must also focus on they're well-being. The game implies a fair number of jumps and landings in all kinds of situations. Thus, to have healthy and well prepared players that can express themselves throughout the season, we have to explore available training methods.

To increase the skeletal muscle's capacity to build strength, new training techniques are continuously applied (Arsenis et al., 2021). Flywheel training devices have initially been used as means of astronaut conditioning on the International Space Station. During long missions, the human musculoskeletal system starts to lose mass being exposed to weightlessness. A 2004 study indicated that this resistance exercise counteracts quadriceps atrophy and lessens the more significant sural triceps muscle atrophy in confined people, and as a result, it should be a valuable tool for astronauts (Alkner & Tesch, 2004). Since then, these systems have started to make their way into strength and conditioning programs, sport performance centers and rehabilitation clinics. Used in performance training it has been found that flywheel isoinertial resistance devices have similar results as weight resistance programs (Arsenis, Gioftsidou, Smilios, Malliou, & Chatzinikolaou, 2020).

The system uses a rotating disc to store the energy during the concentric phase of the movement and converts it to resistance during the eccentric phase. The inertia of the flywheel offers the load of the exercise performed. Given the fact that the force applied depends on the subject's strength and stamina, it can vary between sets and even repetitions as time progresses (Beato, Madruga-Parera, Piqueras-Sanchiz, Moreno-Perez, & Romero-Rodriguez, 2021). With this setup, even if the power declines when fatigue sets in, we might claim that the load is at its maximum for each repetition. Having this in mind, flywheel exercises are beneficial for athletes and untrained people alike, for the young and fit and for the injured or old (Beato, Maroto-Izquierdo, Hernandez-Davo, & Raya-Gonzalez, 2021). The advantage stands in the natural load variation during the exercise. Authors of the research Effect of Flywheel Resistance Training on Balance Performance in Older Adults discovered that flywheel resistance exercise training increased older adults' muscle power while also improving balance and mobility (B. A. Sanudo et al., 2019).

Objective

The objective of the study was to measure the effect of isoinertial exercises using a flywheel training device on lower limb power and stability. Also, we wanted to verify if a positive relation can be found between force, power and stability of the lower limbs.

Materials and Methods

15 female volleyball players age between 16 and 32 were included in the study N=15. During 4 months the subjects trained twice a week using the flywheel device for a total of 32 sessions. The training protocol was structured as following: In the first 4-week cycle, 3 sets of 12 repetitions were performed twice a week. The second cycle had 4 sets of 10 repetitions. The third month contained 4 sets of 8. The last month 5 sets of 6 repetitions were executed also twice a week.

After accommodation with the testing protocol, initial (i) and final (f) tests were performed using OptoJump, Y balance test YBT and the flywheel device's own measuring system, the kMeter2. Following was the sequence of the testing methodology: Y balance test was performed first. After it, 3 countermovement jumps were measured with the best value recorded. Lastly, squat power was assessed from a set of 6 repetitions with only the last 3 maximal reps (3RM) being registered. The first three repetitions are used to set the flywheel in motion.

With OptoJump, the counter movement jump height was measured CMJ (cm). With the Y balance test, the dynamic stability was assessed by calculating the composite reach distance index of the lower quarters, the average was represented by CRD (%). Average squat power AvP(W) and force AvF(N) was measured with the kMeter2 and L flywheel attached (0.050 kgm^2)

The statistical analysis has been performed using SPSS. T test was used to compare the initial and final values of the jump height, lower limb power and lower limb stability. Pearson Correlation was used to verify if the values from the initial and final tests do, or do not correlate in between themselves.

Results

Significant improvement has been found between the initial and final results for composite reach distance index, squat power/force and jump height $p<.01$. We treated each parameter separately and compared the means of the initial and final measurements. The results are represented in the graphs bellow.

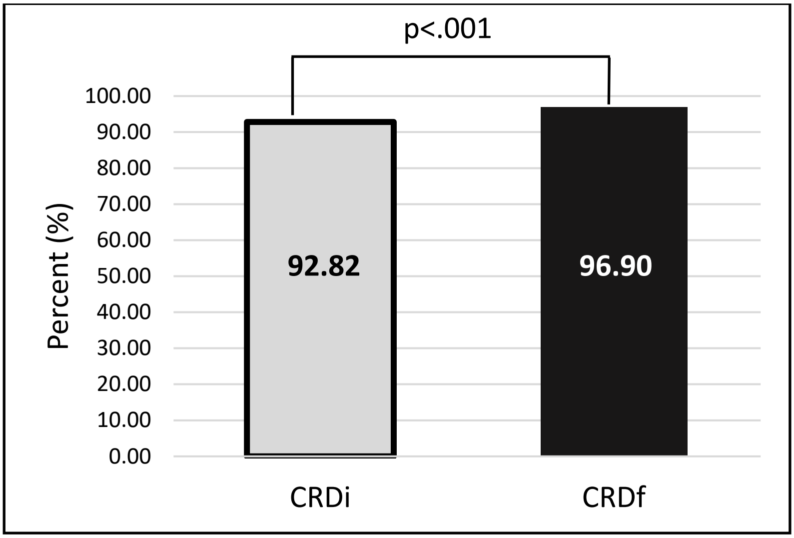

Figure 1. *Composite reach distance index*

We have found an increase of 4.08% between the initial and final measurements for lower limb composite reach distance index. The difference may be small but it is statistically significant with a value of $p<.001$, SD=3.19%.

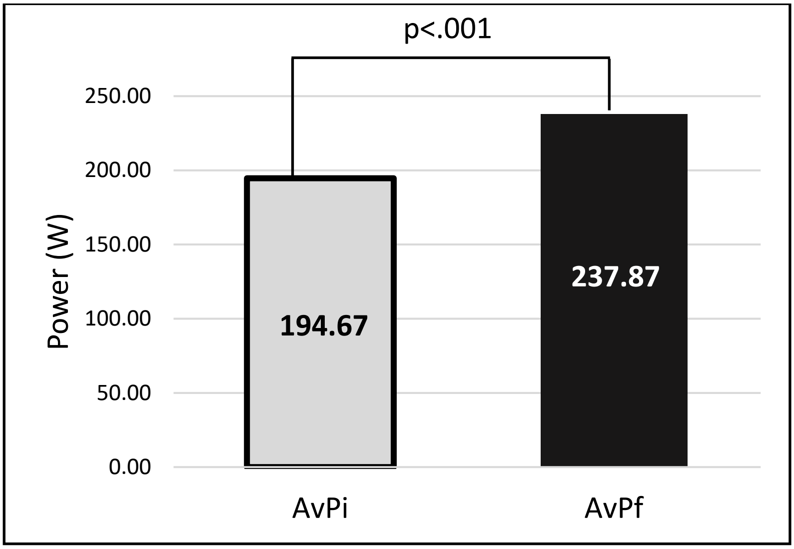

Figure 2. *Average lower limb power*

Using the flywheel device, the increase in average power for the 3 RM squats has been recorded at 43.2 W. The increase is substantial with $p<.001$, SD=32.88 W.

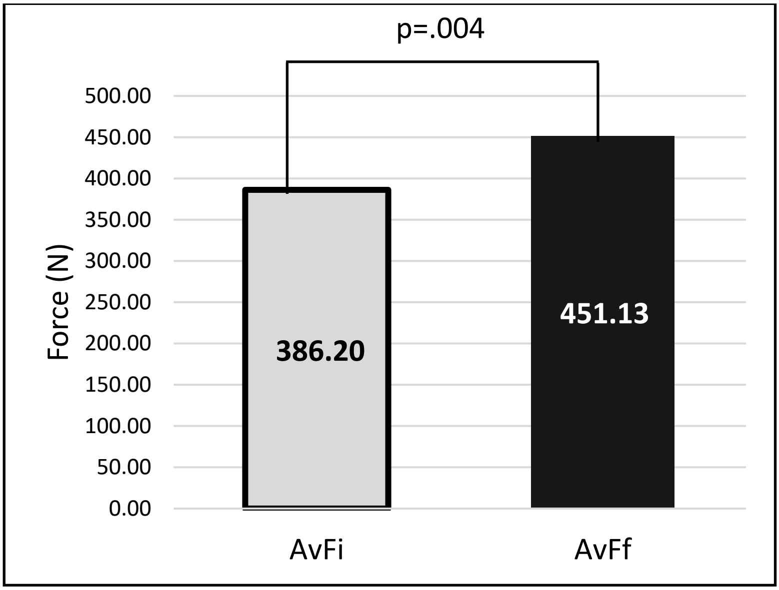

Figure 3. *Average lower limb force*

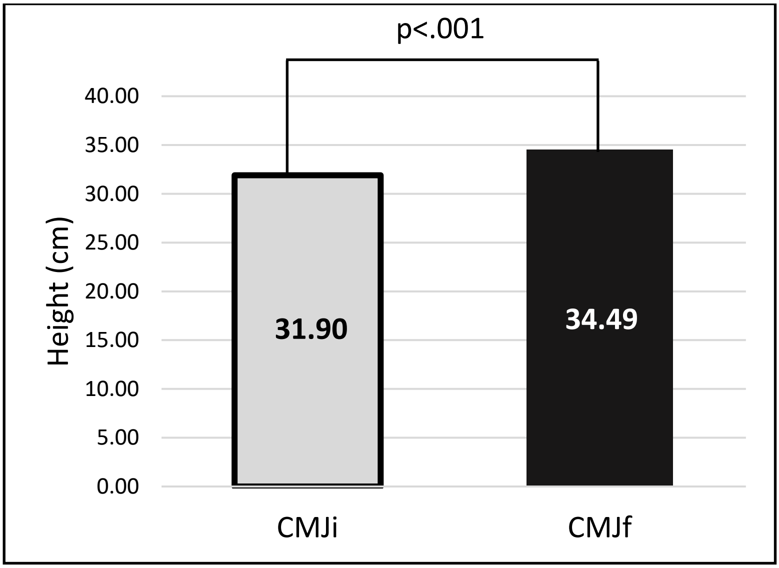

Figure 4. *Counter movement jump height*

An increase can also be observed in the measurement of 3RM squat average force. We found a difference of 64.93 N, p<0.01, SD=72.12 N. The values of the counter movement jump have also increased by a small, but significant amount of 2.59 cm on average p<.001, SD=1.66 cm.

Table 1. Initial measurement correlations

		CRDi	AvPi	AvFi	CMJi
AvPi	Pearson Correlation	0.259	1	0.513	.639*
	Sig. (2-tailed)	0.352		0.050	0.010
	N	15	15	15	15
AvFi	Pearson Correlation	-0.171	0.513	1	0.485
	Sig. (2-tailed)	0.542	0.050		0.067
	N	15	15	15	15

* Correlation is significant at the 0.05 level (2-tailed).

As we expected, in the initial results average power positively correlates with counter movement jump height r=.64, p=.01. At the same time, a slightly weaker correlation can be found between power and force values r=.51, p=.05. This is considered normal, as force is a component of power.

Table 2. Final measurement correlations

		CRDf	AvPf	AvFf	CMJf
AvPf	Pearson Correlation	.271	1	.731**	.549*
	Sig. (2-tailed)	.329		.002	.034
	N	15	15	15	15
AvFf	Pearson Correlation	.461	.731**	1	.665**
	Sig. (2-tailed)	.084	.002		.007
	N	15	15	15	15

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The following associations for the final measurements have been discovered: Again, average power positively correlates (this time stronger) with average force r=.73, p=.002 and with jump height r=.55, p=.03. A slight positive relation is seen between power and stability. Furthermore, we see average force correlating with jump height r=.66, p=.007 and slightly with the composite reach distance r=.46, p=.08.

Discussions

In a 2021 study, it has been found that in comparison to baseline, there were significant differences after training in squat jumps (SJ), and countermovement jumps (CMJ), as well as ratings of felt exertion, heart rate, and reported muscular pain. Additionally, compared to conventional training, the SJ and CMJ were much lower following inertial flywheel training (Lopez De Haro, Olcina Camacho, & Timon Andrada, 2021). Possibly the lather can be more efficient in some cases, when time is of the essence. Another study concluded that flywheel resistance exercise training is a suitable method of exercise for enhancing strength and functional capacity in older adults (B. Sanudo, de Hoyo, & McVeigh, 2022). Besides strength, balance can also be improved as the same author discovered in a different study named Improved Muscle Strength, Muscle Power, and Physical Function After Flywheel Resistance Training in Healthy Older Adults (Sanudo et al., 2022).

A review conducted in 2022 included studies that were conducted between 2004 and 2019. 100 women were involved, volume ranged from 1 to 4 sets and 7 to 12 repetitions, and the frequency ranged from 1 to 3 times per week. The training period spanned from 5 weeks to 24 weeks. According to recent research, flywheel training can improve physical results in both young and old ladies and is both safe and time-efficient. With this knowledge, doctors may be more likely to recommend flywheel training as an effective stimulus for physical improvement as well as an excellent protection against accidents or falls (Raya-Gonzalez, de Keijzer, Bishop, & Beato, 2022).

In comparison to training with only the athletes' own body weight as resistance, a 6-week flywheel routine appears to induce more favorable adaptations that protect athletes from hamstring and ACL injuries and improve their performance during repeated shuttle sprints (Raya-Gonzalez et al., 2022). This is clearly the case of our study, although more data is needed to compare this training system to free weight resistance training.

A study from 2016 that included 8 teams (4 volleyball and 4 basketball for a total of 38 women and 48 men) found that regular workouts can be improved by include a weekly eccentric overload squat training session. This increases lower limb muscle strength without causing patellar tendon complaints.

Future research will examine the effectiveness of the current workout paradigm in sports that frequently require forceful jumping to prevent or treat patellar tendinopathy (Gual, Fort-Vanmeerhaeghe, Romero-Rodriguez, & Tesch, 2016).

Conclusions

A flywheel isoinertial training device can be seen as a viable alternative for power and stability development in female volleyball players. Even though the parameters we tracked improved, we could not identify strong significant correlations between lower limb stability and power/force values.

It has been observed that increasing the lower limb power, although directly correlated with jump height, does not drastically increase the latter. This makes us believe that countermovement jump height is influenced by other factors besides lower limb power and force.

Although correlation does not imply causation, we have found a stronger connection between the stability parameter CRD and force, rather than the power of lower limbs. Future consideration of the issue is necessary.

This system's mobility and safety during use and storage are undoubtedly benefits. Despite not being able to completely replace conventional training, it produces outcomes that are comparable. The conditioning instructor decides how to use a combination of traditional techniques and modern technologies to the athletes' advantage.

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