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Relationship between lower limb power and dynamic stability in volleyball players

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Abstract

Introduction: As in all team sports, lower limb power is an important quality of any player. Especially when it comes to volleyball, a game that relies on jumping performance on almost every action except reception. Another crucially important quality of the lower limbs is dynamic stability. Without the latter, the frequency of injuries rises, and that is something any coach or player wants to avoid. The question arises: Are the two qualities related?

Aim: The study aimed to investigate the correlation between lower limb power and force measured using an inertial flywheel training/measuring device and dynamic stability evaluated through the Y balance test.

Material and method: The Y balance test was used for evaluating the lower limb dynamic stability of 8 Romanian volleyball players. In addition, using an inertial flywheel training system (kBox 4 Pro, Exxentric, Sweden) and kMeter II measuring device the following parameters where measured: average force AvF (N), average power AvP (W), concentric peak power ConPP (W), eccentric peak power EccPP(W). The relative peak power RPP (W/kg) was calculated by dividing concentric peak power by the weight of the volleyball player. The subjects performed 8 maximal squats using the kBox harness and the L (0,05 kgm^2) flywheel

Results: Composite reach distance (CRD) means for the lower limbs have been compared using the t-test and although there is a difference of 1.8%, it isn't significant, ($p<0,001$). We have found a direct correlation between the average composite reach distance and relative peak power ($r=0.71$, $p=0.045$) and also with the average power ($r=0.75$, $p=0.032$) of the lower limbs. The composite reach distance for the right leg correlates with the relative peak power ($r=0.73$, $p=0.036$); average force ($r=0.73$, $p=0.039$), and average power ($r=0.77$, $p=0.024$). For the left leg, however, the only correlation found with the CRD is the average power ($r=0.75$, $p=0.044$).

Conclusions: The medium composite reach distance CRDM is directly correlated with the average lower limb power and relative peak power but due to the small sample size, the power of this effect is unknown. CRDR (right leg) significantly correlates with relative peak power, average power but also with average force whereas CRDL (left leg) only correlates with average power. This does not come as a surprise because all the subjects are right side dominant. There is no significant difference between CRDR and CRDL $p<0.001$. This is quite important because stability asymmetries of the lower limbs may lead to injury.

Key words*: volleyball, dynamic stability, lower limbs, power, Y balance test,*

Rezumat

Introducere: În toate jocurile sportive, puterea membrelor inferioare este o calitate importantă a oricărui jucător. Mai ales când vine vorba de volei, un joc care se bazează pe sărituri în aproape fiecare acţiune, cu excepţia preluării. O altă calitate crucială a membrelor inferioare este stabilitatea dinamică. Fără aceasta din urmă, frecvenţa accidentărilor creşte şi acest lucru este de evitat pentru orice antrenor sau jucător. Se pune întrebarea: Sunt cele două calităţi dependente una de cealaltă?

Scop: Scopul a fost de a investiga relaţia dintre putere/forţă, măsurate cu un aparat inerţial cu volantă şi stabilitatea dinamică evaluată prin testul de echilibru Y.

Materiale şi metodă: Testul de echilibru Y a fost utilizat pentru evaluarea stabilităţii dinamice a membrelor inferioare a 8 jucători de volei români. În plus, utilizând un sistem de antrenament cu volantă inerţială (kBox 4 Pro, Exxentric, Suedia) şi dispozitivul de măsurare kMeter II, au fost măsuraţi următorii parametri: forţa medie AvF (N), puterea medie AvP (W), puterea concentrică maximă ConPP (W) , putere excentrică maximă EccPP (W). Puterea maximă relativă RPP (W / kg) a fost calculată prin împărţirea puterii maxime concentrice la greutatea jucătorului de volei. Subiecţii au efectuat 8 genuflexiuni maximale folosind hamul kBox şi volanta L (0,05 kgm^2)

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Rezultate: Mediile indicilor de stabilitate ai membrelor inferioare au fost comparaţi folosind testul t şi, deşi există o diferenţă de 1,8%, aceasta nu este semnificativă, p <0,001. A fost găsită o corelaţie directă între indicele mediu de stabilitate şi puterea maximă relativă (r = 0,71, p = 0,045), dar şi cu puterea medie (r = 0,75, p = 0,032) a membrelor inferioare. Indicele de stabilitate pentru piciorul drept se corelează cu puterea relativă maximă (r = 0,73, p = 0,036), forţa medie (r = 0,73, p = 0,039) şi puterea medie (r = 0,77, p = 0,024). Cu toate acestea, pentru piciorul stâng, singura corelaţie găsită cu CRD este puterea medie (r = 0,75, p = 0,044).

Concluzii: Există o corelaţie directă între CRDM şi puterea medie a membrelor inferioare respectiv puterea relativă maximă, dar datorită dimensiunii reduse a eşantionului, puterea efectului este necunoscută. CRDR (membru inferior drept) se corelează semnificativ cu puterea maximă relativă, puterea medie, dar şi cu forţa medie, în timp ce CRDL (mediu inferior stâng) se corelează doar cu puterea medie. Acest lucru nu vine ca o surpriză, deoarece toţi subiecţii sunt dreptaci. Nu există nicio diferenţă semnificativă între CRDR şi CRDL (p<0,001). Acest lucru este destul de important deoarece asimetriile de stabilitate ale membrelor inferioare pot duce la accidentări.

***Cuvinte cheie**: volei, stabilitate dinamică, membre inferioare, putere, test de echilibru Y*

Introduction

As in all team sports, lower limb power is an important quality of any player. Especially when it comes to volleyball, a game that relies on jumping performance on almost every action except reception. Another crucially important quality of the lower limbs is dynamic stability. Without the latter, the frequency of injuries rises, and that is something any trainer or player wants to avoid. The question arises: Are the two qualities related?

The Y Balance Test™ (YBT) is a simple, yet reliable, test used to measure dynamic balance. It was developed to standardize the modified Star Excursion Balance Test (mSEBT), improve its practicality, and make it commercially available [1]. Since then, the YBT has gone on to become an extremely popular test due to its simplicity and reliability.

The greatest magnitude forces in muscle occur when an external force exceeds that produced by the muscle and the muscle lengthens, producing an eccentric contraction and negative work [2]. During this phase, the muscle fibers can sustain damage, but this is not an obligatory response. In fact, the ability to produce high forces with eccentric contractions should be viewed as a protective adaptation and stimulus for muscle (and tendon) responses, rather than a common cause of damage. [3]

In a meta study from 2017, flywheel excentric overload training (FW-EOT) adaptations were compared to traditional resistance interventions. A total of 9 studies with 276 subjects and 92 effect sizes were included in the analysis. Significant differences have been found between FW-EOT vs. conventional resistance training in concentric and eccentric strength, muscle power, hypertrophy, vertical jump and running speed favoring the FW-EOT in healthy subjects. [4]

In 2019 in the study *Criterion Validity of Force and Power Outputs for a Commonly Used Flywheel Resistance Training Device and Bluetooth App*

the validity of the kMeter application for measuring force and power was assessed when compared with a criterion measure. A dual force plate and tricamera optoelectronic setup were used as the criterion, while the kMeter app was the practical measuring device.

Large to near perfect relationships were observed with moderate bias. The typical error of the estimate was <10% at all loads.

The study concluded that kMeter app is an acceptable method of monitoring flywheel resistance training and advised practitioners in using average power rather than average force. [5]

Aim and purpose of the study

The aim of the study was to investigate the correlation between lower limb power and force measured using an inertial flywheel training/measuring device and dynamic stability evaluated through the Y balance test.

Material and method

8 volleyball players from a Romanian first league team took part in this study.

The Y balance test was used for evaluating lower limb dynamic stability for both lower limbs. Following the Y balance test procedure [6] we have measured the composite reach distance for both right CRDR and left CRDL legs. The average composite reach distance was calculated and noted as CRDM.

Using an inertial flywheel training system (kBox 4 Pro, Exxentric, Sweden) and kMeter II measuring device the following parameters where measured: average force AvF (N), average power AvP (W), concentric peak power ConPP (W), eccentric peak power EccPP(W). The relative peak power RPP (W/kg) was calculated by dividing concentric peak power by the weight of the volleyball player.

The subjects performed 8 maximal squats using the kBox harness and the L (0,05 kgm^2) flywheel. After the player warmed up, a set of 10 repetitions was performed before the measurement.

The t test was used to compare the means of the stability of the lower limbs. For investigating the correlation of the variables, Pearson's Correlation test was used, considering a strong correlation values $0.5 \leq r < 1$ with $p < 0.05$.

Results

The mean and SD of the parameters measured can be seen in the table below:

Table I. Parameter mean and SD

	Mean	Std. Deviation
CRD_R	90.62	13.11
CRD_L	88.82	13.69
CRD_M	89.72	13.35
R_PP	5.63	1.64
Av_F	624.00	117.40
Av_P	249.62	69.01
Con_PP	491.62	122.11
Ecc_PP	481.25	149.06

CRDR and CRDL means have been compared using the t test and although there is a difference of 1.8%, it isn't significant, (p<0,001), Table I. We can assume that the values for both lower limbs are almost symmetrical with a slight right leg dominance.

Table II. Composite reach distance mean comparison

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference Lower	Upper
CRD R	19.537	7	.000	90.62000	79.6520	101.5880
CRD L	18.341	7	.000	88.82125	77.3699	100.2726

The average composite reach distance was calculated for the right and left leg of each individual and the CRDM value was obtained. This, along with CRDR and CRDL were correlated with the other parameters of power and force as seen in Table III.

Table III. Correlations between CRD and force/power measurments

		R PP	Av F	Av P	Con PP	Ecc PP
CRD_R	Pearson Correlation	.739*	.732*	.776*	.691	.667
	Sig. (2-tailed)	.036	.039	.024	.058	.071
	N	8	8	8	8	8
CRD_L	Pearson Correlation	.694	.662	.721*	.690	.631
	Sig. (2-tailed)	.056	.074	.044	.058	.094
	N	8	8	8	8	8
CRD_M	Pearson Correlation	.719*	.699	.750*	.693	.651
	Sig. (2-tailed)	.045	.054	.032	.056	.080
	N	8	8	8	8	8

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

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

We have found a correlation between CRDM and relative peak power (r=0.71, p=0.045).

Also CRDM directly correlates with average power (r=0.75, p=0.032).

The composite reach distance for the right leg correlates with the relative peak power (r=0.73, p=0.036); average force (r=0.73, p=0.039), and average power (r=0.77, p=0.024).

For the left leg, however, the only correlation found with the CRD is the average power (r=0.75, p=0.044) Table III.

Discussions

Due to the large number of jumping and landing movements, volleyball exerts a high demand on lower limbs, causing a high incidence of injuries. On average, 52% of volleyball injuries occur in lower limbs. Y Balance-test (YBT) is widely used to predict lower limb injury in athletes who jump, so it is important to identify whether the hip and knee stabilizer muscle strength is related to the performance of this test, since muscle strength is important for injury prevention, given the possibility of modifying these factors. [7]

The adaptive mechanisms are not uniformly defined, but apparently, muscle can increase in size and strength and its spring quality can change following chronic exposure to eccentric contractions. The muscle-tendon structure also responds favorably to an eccentric-resistance exercise protocol. These adaptations, which need to be explored further in well-defined, basic, randomized epidemiological studies, play a part in the enhancement of high-

power sports activities, in the prevention and the rehabilitation of musculoskeletal injuries [8]

A relationship between the stability of the lower limbs and force has been found. An even stronger relationship was that between lower limb power and stability. This can further be investigated to find out by what measure the improvement of power positively affects the stability of the lower limbs.

Conclusions

Although correlation does not imply causation, our hypothesis is verified. The CRDM is directly correlated with the average lower limb power and relative peak power but due to the small sample size, the power of this effect is unknown.

CRDR significantly correlates with relative peak power, average power but also with average force whereas CRDL only correlates with average power. This does not come as a surprise because all the subjects are right side dominant.

There is no significant difference between CRDR and CRDL ($p<0.001$). This is quite important because stability asymmetries of the lower limbs may lead to injury.

The inertial flywheel platform is a safe and versatile device. There is no need for resetting large weights transitioning from one subject to the other, thereby saving time. Not only that but it can also be used as a training platform, being portable and needing less space than a basic weightlifting room.

In spite of the fact that our study has its limitations, it brings an insight into a relatively new technology that may, in the near future be the norm in general physical preparation. The device, firstly used in injury rehabilitation can make its way on the court to be used for enhancing power and also in injury prevention.

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