THE BENEFITS OF USING ECCENTRIC CONTRACTIONS IN THE DEVELOPMENT OF THE HAMSTRINGS MUSCLES

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Abstract: *The football game presents a higher risk of injuries compared with other team sports. Due to the nature of the sport, most injuries in football are localized in the lower extremities (almost 70%), with the knee being the most common site with 54% of the injuries. This study aims to obtain the best possible coordination between the tight muscles, increase muscular strength, and reduce the risk of injuries Material and methods: The study included 15 players, average age of 15 years and 6 months, football players. The training included 3 sessions per week of isoinertial training. Each player performed 3 sets of 10 repetitions with a 20-seconds pause between sets on each leg. The isoinertial exercises were performed with the help of the Desmotec device. The recorded data obtained during the training were expressed in Watts (W), and processed with the dedicated software of the Desmotec system. Results: The average power recorded for the right hamstring was 26.3W for concentric contraction and 40.2W for the eccentric contraction, on the left hamstring the average power recorded was 27.06W for concentric contraction and 42.93W for the eccentric contraction. Conclusions: The analysis of these results shows that the eccentric muscle contraction develops more power than the concentric one. Even though most of the players are right-footed, higher values on the left foot were obtained. The goal is to obtain a better balance between the tight's agonist and antagonist muscle groups.*

Keywords: muscle, performance, isoinertial

Introduction

Compared to other team sports, football has the highest risk of injury; 70% of them are located in the lower extremities and muscle injuries are the most common (Fouseki et al.,2011 Ekstrand (Ekstrand et.al., 2011) state that 92% of muscle injuries affect the four major muscle groups of the lower limbs: hamstrings (37%), adductor muscles (23%), quadriceps (19 %) and calf muscles (13%). 16% of reported muscle injuries are repeated injuries that cause longer absences. In particular, because it crosses two joints, the hamstrings and the right femur have a significant risk of injury during fast movements, such as sprinting, stopping, accelerating, changing direction, hitting, landing, etc.

Ignoring the cost, location, and prevalence, it is essential to determine the risk factors that favor injury to address the issue of injury prevention among football players (Ciullo et.al, 1983). Muscle damage can occur due to the interaction of several factors, including intrinsic-internal factors and extrinsic-external factors.

This category includes factors that are related to the athlete and may be modifiable or unchangeable, including age - the risk increases with age and sex - the risk is higher for females due to the more pronounced valgus at the knee joint.

Modifiable internal factors include a history of similar injuries (previous injuries are the main risk factor for a new injury) and physical conditions determined by the development of physical skills such as flexibility, aerobic capacity, endurance, and speed (Ekstrand, 2011).

The literature states that muscle imbalance caused by resistance deficit is the second most important risk factor, as the imbalance of muscle resistance between agonists and antagonists, which is between hamstrings and quadriceps and/or lack of resistance of bilateral hamstrings, is one among the most common factors (Ciullo et al., 1983).

According to Tais (Tais, 2011), the development of muscular resistance occurs when an external force is greater than that produced by the muscles and it is elongated while maintaining contraction, thus creating an eccentric contraction. Eccentric exercise has been shown to reduce the rate of injury, as muscle damage occurs when the length of the muscle fibers exceeds the optimal length; therefore, the lesions can be reduced, if the optimal length can be increased. Studies have shown that this length increases consistently due to eccentric exercise (Clark, 2008).

Eccentric muscle contraction

It is well known that eccentric muscular actions generate greater force at a lower activation level (Moritani, 1987), requires a lower metabolic cost (Bigland-Ritchie, 1976), and expose muscles to more severe injuries than concentric actions do (Gibala, 1995). Thus, it is accepted that muscle injuries often occur while the contracted muscle is suddenly overstretched beyond its limits (Garrett, 1990). Unknown eccentric exercise often leads to muscle damage, whose symptoms include loss of strength, pain, and muscle tenderness (Howell, 1993). Recent data supposed that quickly speed eccentric exercise causes more muscle damage than a slow-speed exercise in untrained players (Chapman, 2006). After the first eccentric exercise and after complete recovery, a repeated bout of the same exercise results in minimal symptoms of muscle damage and has been named the "Repeated bout effect (RBE)" (Nosaka, 1995). The exact mechanism of this adaptation is not well defined, but it seems to involve neural, mechanical, and cellular adaptations (McHugh, M. P., 2003). However, if the muscle failure threshold increases and the attenuation of loads are increased, a protective effect may occur (Clarkson, 1992). Interestingly, this repeated fighting effect can take several months (Nosaka, 2001). These are the main reasons why eccentric training is accepted as a preferred model for preventing muscle injuries (LaStayo, 2003).

The YoYo flywheel technology

The use of inertia wheels to provide strength is not new. As early as 1922, Nobel laureate Archibald V. Hill used a heavy flywheel to analyze muscle work and its mechanical efficiency (Hill, 1992). In this classic study, the variation of the equivalent load of the system was obtained by wrapping a string around one of the eight pulleys of different sizes. However, this device was only designed to provide resistance during the concentric phase. The operating principle of the YoYo Flywheel Technology device is based on a flywheel with a fixed axis on a frame. One strap is wrapped around its shaft, and the other end is attached to the footrests, handles, or a harness attached to the strap. The strap is pulled full length during a concentric muscular action, rotating a flywheel. At the end of the concentric action, the flywheel continues to spin by its inertia and retracts the strap, pulling back the student's limb. After initially letting the belt unwind, the student then resists, decelerating the flywheel until all previously accumulated kinetic energy has been dissipated and the flywheel has stopped completely. Because such an eccentric action is exerted at a lower angular displacement than in the concentric action, while the energy is the same for both actions, the eccentric torque is greater than the concentric one, thus producing an eccentric overload (Alkner, 2005). An advantage of flywheel devices is that the resistance is virtually unlimited and adjusts automatically because the flywheel adapts by opposing its inertia to any force exercised. This also means that all repetitions in an exercise are in fact maximum and that the athlete can train to exhaustion, even though strength production decreases with fatigue. For the same reason, the steering wheel can also accommodate variations in the force in the range of motion (for example, due to the different biomechanical efficiency at different angles of the joints). This is not the case with conventional weight-based training devices, which instead offer a constant resistance equal to the load.

Hamstrings study.

The hamstrings are important extensors of the hip and knee flexors while walking, but they also have the role of braking this joint when the foot hits the ground in a running cycle. The hamstring muscles continue to be a difficult and often frustrating problem for sports of large caliber. Several studies have reported that this injury is the most common in athletics, professional football, and American and Australian football. It was also found that the re-injury rate is between 12 and 31% (Heiser, 1984). Many authors suggest the use of dynamic eccentric exercises to prevent and /or rehabilitate hamstring injuries. (Agre, 1985).

One of the most interesting studies on the prevention of hamstring injuries in elite athletes was conducted by Carl Askling et al. (Askling, 2003) from the Karolinska Institutet. In this study, thirty footballers from two of the best Swedish teams in the first league were recruited and randomly assigned to either a training group or a control group. A group of players performed 16 specific exercise sessions for the hamstring muscles, using a treadmill for short-stretch hamstring training during the pre-season (4 sets of 8 reps). Another group did not perform any additional activities or specific exercises for the hamstring muscles, serving as a control group. At the end of the season, the training group suffered 3 hamstring injuries compared to 10 in the control group. In addition, the first hamstring injury in the training group appeared only 4 months after the end of the training. Moreover, the players in the training group found a significant increase in muscle strength and running speed at 30 m. Any experienced coach knows how difficult it is to increase sprint speed in already well-trained football players.

Material and method

Players

The study included 14 players, average age of 14 years and 10 months, football players. The training included 3 sessions per week of isoinertial training. Each player performed 3 sets of 10 repetitions with a 20-seconds pause between sets on each leg. The isoinertial exercises were performed with the help of the Desmotec device. The recorded data obtained during the training were expressed in Watts (W), and processed with the dedicated software of the Desmotec system.

The first measurement took place in October 2021, and the second one took place 6 months later.

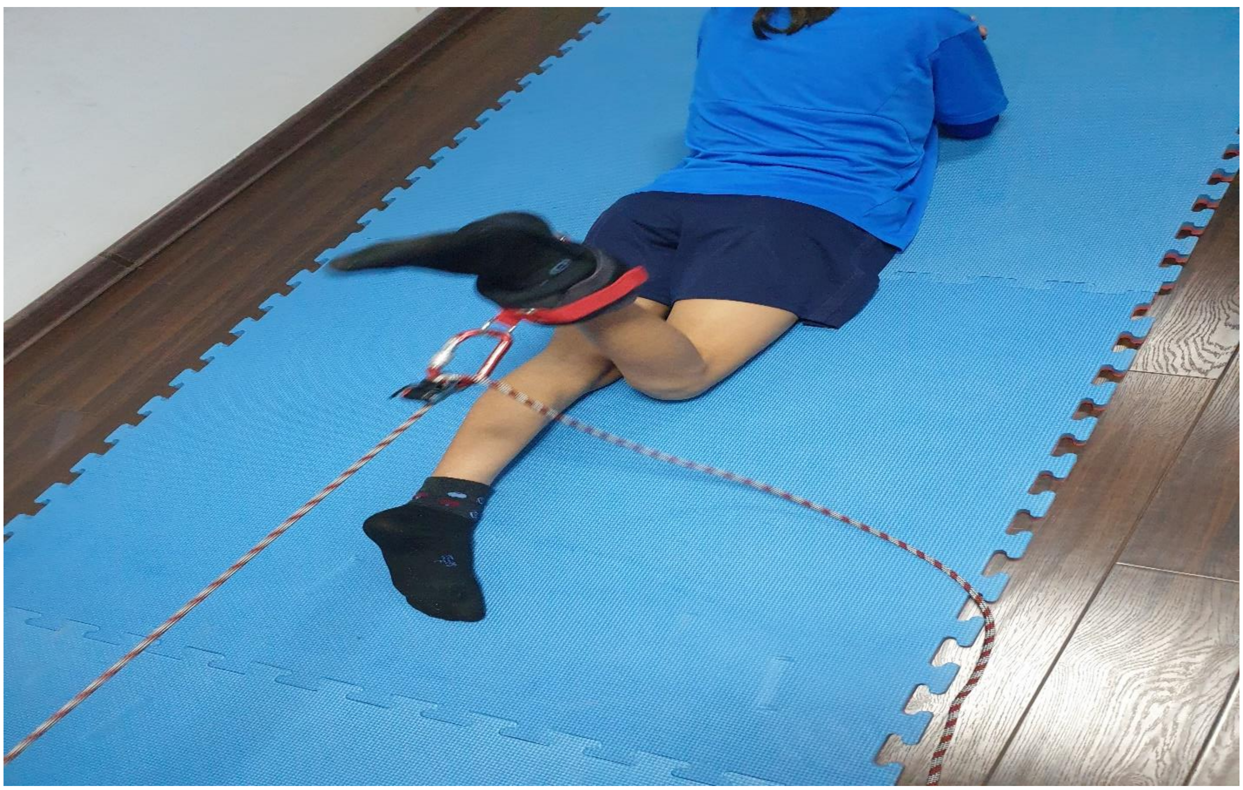

Figure 1. Players in ventral decubitus performing the knee flexion. The anklet is positioned on the distal part of the tibia and attached to a rope that is connected to the device.

Figure 2. Different Desmotec inertial disc. The smaller discs (small, medium) are usually used for coordination development, meanwhile, the heavy ones (large, pro) are used for improving muscle strength and for injury prevention.

Figure 3. The Desmotec device – V.LINE Model

Measurement results with Desmotec device for the left and right hamstrings – Initial period

Nr.Crt	**Age**	**Concentric average power (L)**	**Eccentric average power (L)**	**Concentric average power (R)**	**Eccentric average power (R)**
1	16 years and 5 months	18W	34W	22W	37W
2	14 years and 7 months	22W	35W	25W	36W
3	15 years and 7 months	21W	43W	23W	42W
4	14 years and 7 months	29W	34W	26W	32W
5	16 years	33W	41W	19W	26W
6	15 years and 11 months	32W	61W	32W	33W
7	14 years and 10 months	20W	21W	17W	18W
8	17 years and 5 months	32W	60W	30W	47W
9	15 years and 7 months	38W	84W	39W	78W
10	14 years and 2 months	42W	73W	50W	80W
11	11 years and 10 months	24W	40W	21W	32W
12	12 years and 10 months	21W	25W	17W	24W
13	14 years and 1 month	26W	30W	28W	48W
14	13 years and 11 months	29W	31W	25W	31W
Media	14 years and 10 months	27.13W	42.2W	26.33W	40.2W

Tabel 1. Average concentric and eccentric power developed by left and right hamstrings, the initial period

Measurement results with Desmotec device for the left and right hamstrings – Final period

Nr .Crt.	Age	Concentric average power (L)	Eccentric average power (L)	Concentric average power (R)	Eccentric average power (R)
S1	15 years and 11 months	41W	74W	50W	87W
S2	15 years and 1 month	29W	41W	31W	49W
S3	16 years and 1 month	68W	96W	65W	100W
S4	15 years and 1 month	28W	32W	30W	37W
S5	16 years and 6 months	42W	66W	38W	49W
S6	16 years and 5 months	38W	55W	38W	61W
S7	15 years and 4 months	33W	59W	34W	51W
S8	17 years and 11 months	55W	114W	60W	115W
S9	16 years and 1 month	58W	111W	65W	149W
S10	14 years and 8 months	48W	82W	54W	82W
S11	12 years and 4 months	27W	37W	30W	39W
S12	13 years and 4 months	23W	35W	20W	36W
S13	14 years and 7 months	45W	77W	49W	94W
S14	14 years and 5 months	33W	45W	37W	56W
Media	15 years and 4 months	40.57W	66W	42.92W	71.78W

Tabel 2. Average concentric and eccentric power developed by left and right hamstrings, the final period

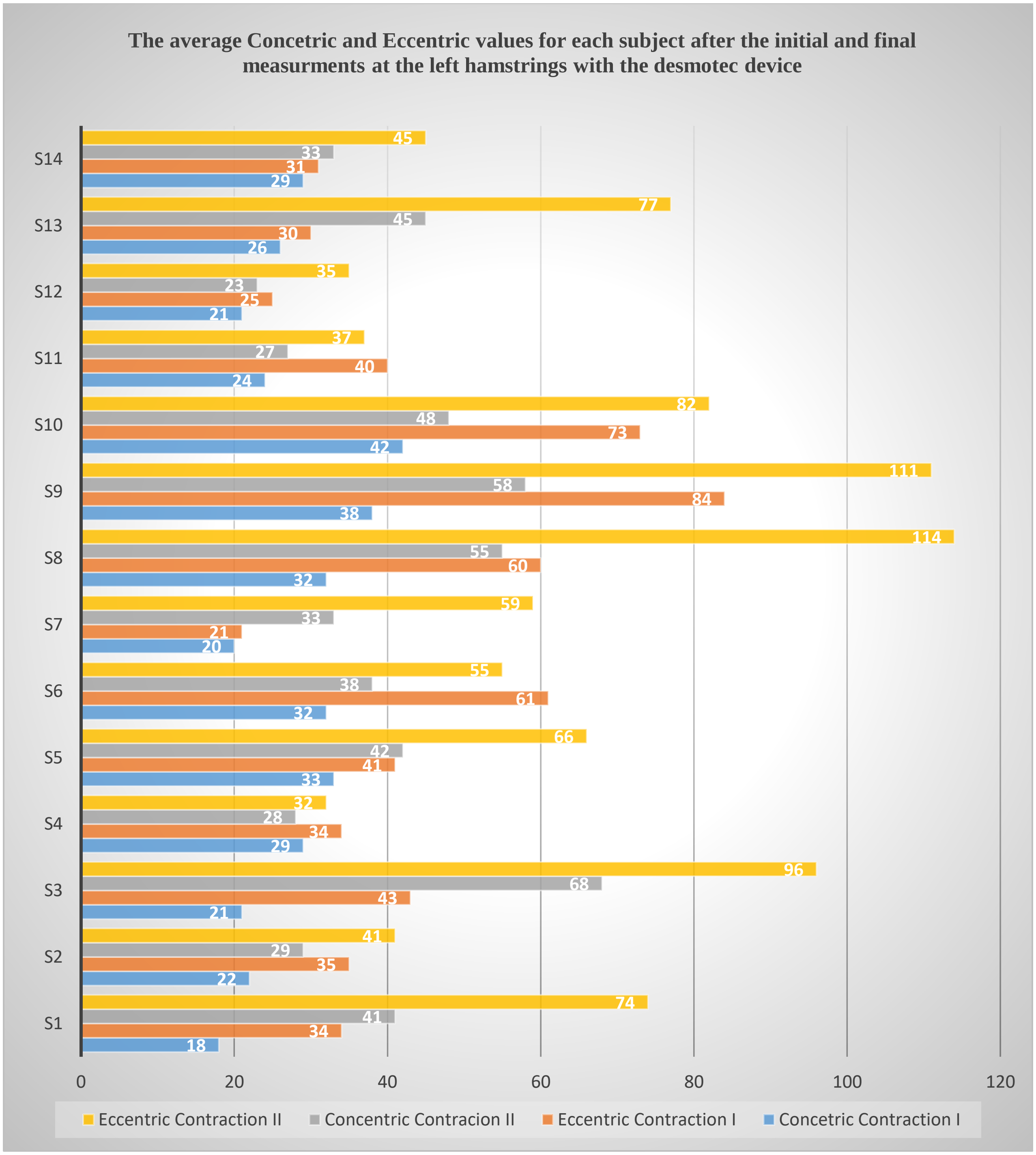

Figure. 4 The average Concentric and Eccentric values for each player after the initial and final period measured at the left hamstring *Note: values are expressed in watts*

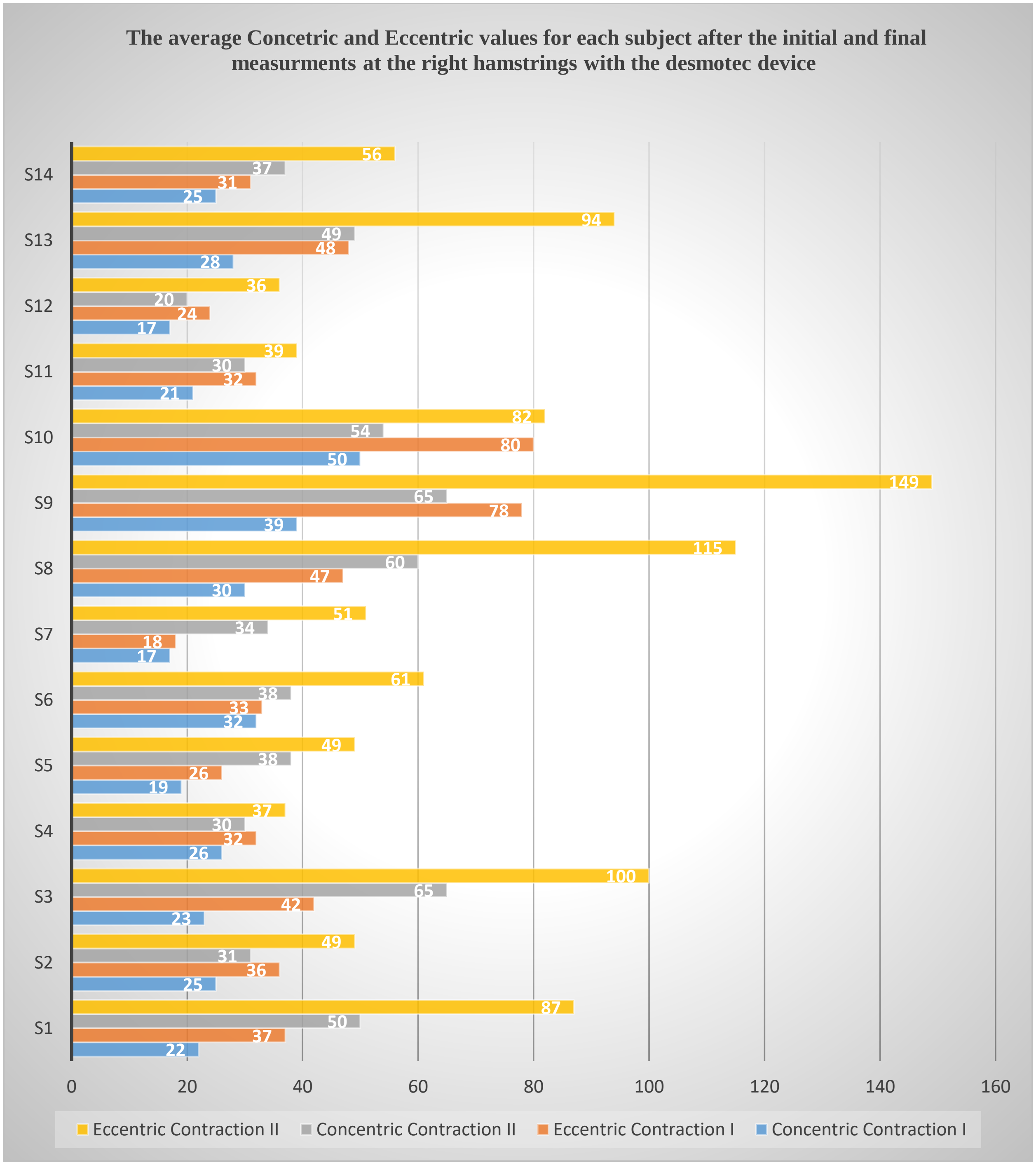

Figure. 5 The average Concentric and Eccentric values for each player after the initial and final period measured at the right hamstring *Note: values are expressed in watts*

Results

The initial study showed that the average concentric powers developed from the left and the right hamstrings are almost equal, on the other side the average eccentric values of the left hamstrings are bigger than the right hamstrings, even if the most players are right-footed.

The average measurement for the left hamstring was 27.13W in the concentric phase, while the average measurement for the right hamstring was 26.33W. On the eccentric phase, were obtained 42.2W for the left foot, meanwhile, for the right foot, 40.2W. The higher values were recorded on the left foot, even though most players are right-footed. The ratio between concentric and eccentric contraction is approximately equal, which means that there is a good muscle balance.

In the final evaluation, there were significant improvements in the average values of both the left and right hamstrings. The average value of the concentric contraction developed at the level of the left hamstring increased by 13.44W, and the eccentric contraction increased by 23.8W, following these results it was found that the eccentric contraction registered greater progress. The average value of concentric contraction developed at the level of the right hamstring increased by 16.59W, and the eccentric contraction increased by 31.78W, following these results it was found that the eccentric contraction registered greater progress in the right hamstring.

The highest increases were recorded by S1, S8, S9, and S13, the average value of each type of contraction, both right and left hamstrings increased by at least 20W. S3 recorded the largest increase in the average value of concentric contraction in both the left and right hamstrings (+47W for the left hamstring and +42W for the right one); The S8 recorded the largest increase in the average value of the eccentric contraction at the left hamstring (+54W), and the largest increase in the average value developed at the right hamstring by the eccentric contraction was recorded by the S9 (+71W).

On the other side, S10 and S11 recorded similar values to the first assessment, the increases being very small, this is also true for S5, except for the average value of the eccentric contraction at the level of the right hamstring, which increased by 28W.

Conclusions

Isoinertial technology is an important method for rehabilitation and injury prevention. This technology offers superior eccentric loads compared to traditional methods, where the co-activation of the hamstring muscles is greater. Generating large eccentric loads provides improved strength and speed in the muscles, which is enhanced by reducing the moment of inertia (Romero-Rodríguez et al., 2010). These effects are achieved at the end of the concentric action and allow the player to slow down, thus increasing the eccentric overload by decreasing the angular displacement (Brasileiro et al., 2011). In terms of injury prevention, the biceps femoris, which has the highest rate of injury reported a reduced incidence, this is possible because the isoinertial technology yo-yo device generates a considerable increase in strength of the biceps femoris muscle for greater activation, this may suggest that the biceps femoris play a more important role in braking than the semitendinosus muscle. (Romero-Rodríguez et al., 2010). players recorded progress, also the measurements reported that the average eccentric contractions develop more power than de concentric ones.

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