Original Article

Myoelectrical properties of lower limbs, in soccer players compared to different fall height and use of additional weight in a Sledge machine

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Abstract

The purpose of the present study was to evaluate the jump ability on a specifically constructed force sledge machine, and compared it to different fall height and use of additional weight on Myoelectrical properties of lower limbs. The subject was 10 amateur soccer players, age $22 \pm 0,6$ years old, weight $76 \pm 2,7$ kg and height $1.80 \pm 0,16$ cm. For the recording of data, a force plate with piezoelectric crystals, type Kistler 9281 C, was used. For the registration of variables they were also used: a) surface electrodes (motion control co. 1000Hz) with preamplifier (which recorded the electro muscle activity from under limbs) and b) construction of a ramp. The Subject performed vertical jumps Drop Jump (DJ), Squat Jump (SJ) and Counter Movement Jump (CMJ) from different height, initially only with body weight and then using additional weight. The EMG analysis of the data was made using the software APAS XP and the comparison between groups was carried out by using the statistical package SPSS 15. Initially, descriptive statistics methods were used, to calculate average, standard deviation and standard error of the mean and the subsequent statistical inference methods. To examine the correlation between the jumps on the selected variables the Pearson's coefficient was used. Differences between variables will be tested at significance level $p \leq .05$. The results of this study confirm that a strong correlation exists between all kinds of jumps.

Keywords: Vertical jump, jumping ability, sledge machine, EMG.

Introduction

The stretch-shortening cycle (SSC) is an efficient muscular activation type characterized by stretching of the target muscle (eccentric phase) prior to a subsequent shortening in the concentric phase. When compared with concentric actions without preceding stretch, muscular force and power of the SSC is enhanced (Cavagna, G.A., Saibene, F.P. & Margaria, R. 1965; Gregor, R.J., Roy, R.R., Whiting, W.C., Lovely, R.G., Hodgson, J.A. & Edgerton, V.R. 1988). Comparisons of the force-velocity curves in constant velocity and in natural locomotion conditions have shown that muscular output can be enhanced by a stretch-shortening cycle (SSC) muscle function. This has been shown in different experimental set-ups (Gregor, et al., 1988; Stevens E.D 1993, Komi P.V. 2000). The force-velocity curve of a muscle is distinct from torque-angular velocity curve that has often been used in human studies to describe the mechanical output of the muscles. Those studies have also shown enhancement of joint torque in the concentric phase of SSC type exercise (Bobbett, M.F., Gerritsen, K.G., Litjens, M.C. & Van Soest, A.J. 1996).

Literature suggests that in addition to myo-electrical potentiation (Bosco, C., Viitasalo J.T., Komi, P.V., & Luthanen, P. 1982), the enhanced force and power output in SSC exercise may arise from a stretch-induced force enhancement phenomenon observed in the contractile level (Ettema, G.J.C., Huijting, P.A. & De Haan, A. 1992, Stevens E.D. 1993), or from effective tendon stretch and recoil. During locomotion in vivo, the interaction between the length of contractile and non-contractile tissues depends on the patterns of neural activity that are highly variable between tasks. Constantly changing muscle length, velocity and force make it difficult to attribute the potential enhancement to any specific factor. In spite of these difficulties, our aim was to examine the contribution of the contractile and the elastic components to the potentiation of the muscle-tendon output using in vivo tendon force and fascicle length measuring techniques in human subjects. Force-velocity relationships were compared between maximal knee joint extension exercises and the data recorded during natural movement both at the level of vastus lateralis (VL) muscle fascicle and at the level of the entire muscle-tendon unit (MTU). The data during natural movements, consisting counter movement jumps (CMJ) and drop jumps (DJ) on a sledge apparatus, has been partially reported earlier (Finni, T., Ikegawa, S., Lepola, V. & Komi, P.V.. 2001).

A reliable way to assess the vertical jump (drop jumps and counter movement jumps) in cases where it is not possible to perform the simple form, or to prevent injury or because of the high level of difficulty, is to use

a ramp construction sledge machine (SLM), where subjects can execute jumping repeat in a seated position, ensuring the stability and balance of the body, including the joints of the hip, knee and ankle, and to achieve a safe jump without risk of injury. It also facilitates the determination of the height of fall, setting the angle required for the execution of the jump, and putting extra weight. There are several reports in the literature concerning investigations which studied the ability and jump muscle function in relation to the drop height and the use of additional weight (Gissis, I., Grezios, A. Goehner, U., & Dickuth H.H., 2003; Gissis, I., Grezios, A., Goehner, U., Dickuth, H.H., & Papadopoulos Ch., 2004), through various situations jumps where you will find the use of construction ramp. The purpose of this study was to examine the effect of the fall of extra weight for selected parameters for the reactive capability in the sledge apparatus built for the purpose.

In the literature also we can see that these structures were used to facilitate the procedures, when the drop height was large enough, (Galindo, A., Barthélemy, J., Ishikawa, M., Chavet, P., Martin, V., Avela, J., Nicol, C., 2009; Hoffrén, M., Ishikawa, M., & Komi, P.V., 2007; Sousa, F., Ishikawa, M., Vilas-Boas, J.P., & Komi, P.V., 2007), also had take place when the jump with an extra large load, (Kubo, K., Morimoto, M., Komuro, T., Yata, H., Tsunoda, N., Kanehisa, H., & Fukunaga, T., 2007; Comyns, T.M., Harrison, A.J., Hennessy, L.K., & Jensen, R.L., 2007), but when there was a great mix of fall and add a big load in the execution of jumps (Horita, T., Komi, P.V., Nicol, C., & Kyröläinen, H., 1999). Even to avoid injuries after jumping performance fatigue protocols (Regueme, S.C., Barthélemy, J., & Nicol, C. 2007; Kuitunen, S., Kyröläinen, H., Avela, J., & Komi, P.V., 2007), to perform jumps with one leg only (Flanagan, E.P., & Harrison, A.J., 2007)., But jumps to people during rehabilitation from injury (Flanagan, E.P., Galvin, L., & Harrison, A.J., 2008).

Material & methods

Participants

Ten healthy amateur soccer players, (age $22 \pm 0,6$ years old, weight $76 \pm 2,7$ kg and height $1.80 \pm 0,16$ cm) with no history of neurological injuries or diseases, gave written consent to participate in this study. None of the participants had engaged in systematic strength training in the 6 months before the experiments began, but some were active in recreational sports. Approval for the project was obtained from the committee on human research at the Aristotle University of Thessaloniki. All procedures used in this study were in conformity with the Declaration of Helsinki.

Sledge apparatus

The execution of jumps took place in sledge apparatus comprising by a support base, a body construction, height adjustable arms, sliding rails, the seat and the force platform. The entire system is made of metal sheet. At the bottom is the support base, which is a lattice of iron and builds the system. The body structure is made of sheet metal. In the rear underside of the arms are set, that allow us to regulate the height of fall, and the angle of fall. Along the upper surface there are two rails, sliding rails, where the seat which use four wheel moves over them. There are seat belts for the attachment of the subject and mechanisms for placing extra weight. At the ends of leads in the movement of the seat is mounted a force plate, with piezoelectric crystals, Kistler 9281C, with sampling frequency 1000 Hz, for recording and evaluation of desired variables forces.

Fig 1: Sledge apparatus

Table 1: Mechanical properties of the sledge apparatus: m = mass of investigational and mass of the seat, F_g = gravitational force, F_{ab} = Force of slide, F_r = friction, S_1 = initial position, S_2 = final position, $ds = S_1 - S_2$ = range of motion, $dh = H_1 - H_2$ = drop height, a = angle of plane

Electromyography

To record the electrical activity of muscles of the legs, 3 surface electrodes was used, with preamplifier (motion control co.). Each active electrode is connected directly to the card, which convert analog signals to digital, and which was common to forceplate and electromyography. Jumps used the card ARIEL Analog / digital input-16A/Dchannels and MJID card AMTI 32channel analog data, 2006, version 2.02. The muscles which recorded the electromyographic activity were the the rectus femoris (RF), the biceps femoris (long head), (BF) and gastrocnemius (GAS). These muscles were selected because they have been found to be the mainly responsible for performing the vertical jump and thus to propel the foot (Van Soest et al., 1993). For extracting EMG features, the raw signal from each muscle originally recorded and it fully underwent normalization by passing it through a filter of low frequencies. The rate cut was at 100 Hz (at frequencies above this frequency embedded noise). Since the bandwidth of all active electrodes starting from 8 Hz, automatically cut off all signals (including interference from traffic) was lower than the frequency. The rectification (rectify) and further processing of electromyographic signals was done with the math program for the comparison of electromyographic data used in the RMS (Root Mean Square) of EMG signals in phase momentum in all measurements (isokinetic, isometric and jumps). The RMS (EMG), according to De Louca (1997), has a physical meaning and it has better strength signal in dynamic muscle activity volitional produced and this are the square root of the integral of the square of the EMG potential with respect to time.

Variables

1	NO ADDITIONAL WEIGHT	SJ	CMJ	DJ40	DJ80	DJ120
RMS	Rectus Femoris Preactivation	RFPRE				
RMS	Rectus Femoris Activation	RFACT				
RMS	Rectus Femoris Max	RFMAX				
RMS	Biceps Femoris Preactivation	BFPRE				
RMS	Biceps Femoris Activation	BFACT				
RMS	Biceps Femoris Max	BFMAX				
RMS	Gastrocnemius Preactivation	GASPRE				
RMS	Gastrocnemius Activation	GASACT				
RMS	Gastrocnemius Max	GASMAX				

Table 2.

2	ADD 1/3 OF BODY WEIGHT	SJ	CMJ	DJ40	DJ80	DJ120
RMS	Rectus Femoris Preactivation	RFPRE2				
RMS	Rectus Femoris Activation	RFACT2				
RMS	Rectus Femoris Max	RFMAX2				
RMS	Biceps Femoris Preactivation	BFPRE2				
RMS	Biceps Femoris Activation	BFACT2				
RMS	Biceps Femoris Max	BFMAX2				
RMS	Gastrocnemius Preactivation	GASPRE2				
RMS	Gastrocnemius Activation	GASACT2				
RMS	Gastrocnemius Max	GASMAX2				

Table 3.

3	ADD 1/2 OF BODY WEIGHT	SJ	CMJ	DJ40	DJ80	DJ120
RMS	Rectus Femoris Preactivation	RFPRE3				
RMS	Rectus Femoris Activation	RFACT3				
RMS	Rectus Femoris Max	RFMAX3				
RMS	Biceps Femoris Preactivation	BFPRE3				
RMS	Biceps Femoris Activation	BFACT3				
RMS	Biceps Femoris Max	BFMAX3				
RMS	Gastrocnemius Preactivation	GASPRE3				
RMS	Gastrocnemius Activation	GASACT3				
RMS	Gastrocnemius Max	GASMAX3				

Table 4.

4	ADD 1/1 OF BODY WEIGHT	SJ	CMJ	DJ40	DJ80	DJ120
RMS	Rectus Femoris Preactivation	RFPRE4				
RMS	Rectus Femoris Activation	RFACT4				
RMS	Rectus Femoris Max	RFMAX4				
RMS	Biceps Femoris Preactivation	BFPRE4				
RMS	Biceps Femoris Activation	BFACT4				
RMS	Biceps Femoris Max	BFMAX4				
RMS	Gastrocnemius Preactivation	GASPRE4				
RMS	Gastrocnemius Activation	GASACT4				
RMS	Gastrocnemius Max	GASMAX4				

Table 5.

Test Protocol

The tests performed in jumps without compliant motion (SJ) and jumps with compliant motion (CMJ) a) without the extra weight placement, b) by placing 1/3 the weight of the tested c) deposit of 1 / 2 the weight of the investigational, d) by placing 1/1 by weight of the investigational. Also depth jumps (DJ) from a height of 40cm, 80cm, and 120cm, a) without the extra weight placement, b) by placing 1/3 the weight of an investigational, c) by placing 1/2 the weight of the investigational, d) placement of 1/1 by weight of the investigational.

Procedure

The subject during the measuring process throughout the course of the test was wearing slacks and athletic sneakers. For increasing neuromuscular preparation and a minimization of the likelihood of injury the subject follows a warm up, stretching exercises and exercises in an ergometer cycle. During jumps, subjects were in seated position and seat belted in the SLM style. Their hands were crossed at waist or chest to avoid any involvement, legs were stretched during the fall and in contact with the force platform. Originally performed in three successive attempts by jumping ramps compliant motion without (SJ) jumps submissive movement (CMJ) and depth jump (DJ) from a height of 40cm, 80cm, 120cm and without placing extra weight, then followed the same cycle other jumps three times once by adding 1/3 the weight of the body being tested a second time by placing an extra 1/2 the weight of the body being tested, and finally by placing 1/1 body weight of the investigational. Between the jumps were two breaks to avoid fatigue phenomena and the entire test were monitored by experts who guided them strictly.

Statistical analysis

The review concerns the comparison between groups and was carried out using the statistical package SPSS 15. Initially, descriptive statistics methods were used, to calculated average, standard deviation and standard error of the mean and the subsequent statistical inference methods. To examine the correlation between the jumps on the selected variables the Pearson's coefficient was used. Differences between variables was tested at significance level $p \leq .0.5$.

Results

The results of our study showed a strong correlation between the variables selected by the different tests in vertical jumps. The following tables detail the results there are for each of the tests.

Test results SJ.

(Table 6).

As we can see in the table 6, there is a strong correlation between test (sj) without additional weight and test with 1/3 add of bodyweight

SJ	SJ2			SJ	SJ3			SJ	SJ4		
NO ADDITIONAL WEIGHT	ADD 1/3 OF BODY WEIGHT	r	p	NO ADDITIONAL WEIGHT	ADD 1/2 OF BODY WEIGHT	r	p	NO ADDITIONAL WEIGHT	ADD 1/1 OF BODY WEIGHT	r	p
BFPRE	BFPRE2	1,000(**)	0,000	BFMAX	BFMAX3	,817(**)	0,004	GASMAX	GASMAX4	,997(**)	0,000
BFACT	BFACT2	1,000(**)	0,000	GASMAX	GASMAX3	,771(**)	0,009				
BFMAX	BFMAX2	1,000(**)	0,000								
GASPRE	GASPRE2	1,000(**)	0,000								
GASACT	GASACT2	1,000(**)	0,000								
GASMAX	GASMAX2	1,000(**)	0,000								

Table 6.

Test results CMJ.

(Table 7).

As we can see in the table 7, there is a strong correlation between tests without additional weight and all the other vertical jump tests in Counter Movement Jump.

CMJ	CMJ2			CMJ	CMJ3			CMJ	CMJ4		
NO ADDITIONAL WEIGHT	ADD 1/3 OF BODY WEIGHT	r	p	NO ADDITIONAL WEIGHT	ADD 1/2 OF BODY WEIGHT	r	p	NO ADDITIONAL WEIGHT	ADD 1/1 OF BODY WEIGHT	r	p
BFPRE	BFPRE2	1,000(**)	0,000	BFPRE	BFPRE3	1,000(**)	0,000				
BFACT	BFACT2	1,000(**)	0,000	BFACT	BFACT3	1,000(**)	0,000				
BFMAX	BFMAX2	1,000(**)	0,000	BFMAX	BFMAX3	1,000(**)	0,000				
GASPRE	GASPRE2	-.824(**)	0,003	GASPRE	GASPRE3	-.824(**)	0,003	GASPRE	GASPRE4	-.845(**)	0,002
GASACT	GASACT2	.968(**)	0,000	GASACT	GASACT3	.978(**)	0,000	GASACT	GASACT4	.988(**)	0,000
GASMAX	GASMAX2	1,000(**)	0,000	GASMAX	GASMAX3	.988(**)	0,000	GASMAX	GASMAX4	.988(**)	0,000

Table 7.

Test results DJ40.

(Table 8).

In the table 8, there is a strong correlation between tests without additional weight and all the other vertical jump tests in Drop Jump 40.

DJ40	DJ402			DJ40	DJ403			DJ40	DJ404		
NO ADDITIONAL WEIGHT	ADD 1/3 OF BODY WEIGHT	r	p	NO ADDITIONAL WEIGHT	ADD 1/2 OF BODY WEIGHT	r	p	NO ADDITIONAL WEIGHT	ADD 1/1 OF BODY WEIGHT	r	p
RFPRE	RFPRE2	.712(*)	0,021	RFPRE	RFPRE3	.822(**)	0,004	RFPRE	RFPRE4	.988(**)	0,000
RFACT	RFACT2	.836(**)	0,003	RFACT	RFACT3	.790(**)	0,006	RFACT	RFACT4	.638(*)	0,047
RFMAX	RFMAX2	1,000(**)	0,000	RFMAX	RFMAX3	.671(*)	0,034	RFMAX	RFMAX4	.771(**)	0,009
BFPRE	BFPRE2	0,270	0,451	GASPRE	GASPRE3	.978(**)	0,000	GASPRE	GASPRE4	.986(**)	0,000
BFACT	BFACT2	0,456	0,185	GASACT	GASACT3	.981(**)	0,000	GASACT	GASACT4	.989(**)	0,000
BFMAX	BFMAX2	.669(*)	0,034	GASMAX	GASMAX3	.965(**)	0,000	GASMAX	GASMAX4	.984(**)	0,000

Table 8.

Test results DJ80.

(Table 9).

In the table 9, there is a strong correlation between tests without additional weight and all the other vertical jump tests in Drop Jump 80.

DJ80	DJ802			DJ80	DJ803			DJ80	DJ804		
NO ADDITIONAL WEIGHT	ADD 1/3 OF BODY WEIGHT	r	p	NO ADDITIONAL WEIGHT	ADD 1/2 OF BODY WEIGHT	r	p	NO ADDITIONAL WEIGHT	ADD 1/1 OF BODY WEIGHT	r	p
RFPRE	RFPRE2	.980(**)	0,000					RFPRE	RFPRE4	.797(**)	0,006
RFACT	RFACT2	.917(**)	0,000					RFACT	RFACT4	.789(**)	0,007
RFMAX	RFMAX2	.661(*)	0,037					RFMAX	RFMAX4	1,000(**)	0,000
BFPRE	BFPRE2	-.949(**)	0,000	BFPRE	BFPRE3	-.949(**)	0,000	BFPRE	BFPRE4	-.785(**)	0,007
BFACT	BFACT2	-.660(*)	0,038	BFACT	BFACT3	-.660(*)	0,038	BFACT	BFACT4	.798(**)	0,006
BFMAX	BFMAX2	.666(*)	0,036	BFMAX	BFMAX3	.666(*)	0,036	BFMAX	BFMAX4	.666(*)	0,036
GASPRE	GASPRE2	1,000(**)	0,000	GASPRE	GASPRE3	-.985(**)	0,000	GASPRE	GASPRE4	.975(**)	0,000
GASACT	GASACT2	1,000(**)	0,000	GASACT	GASACT3	-.994(**)	0,000	GASACT	GASACT4	.863(**)	0,001
GASMAX	GASMAX2	1,000(**)	0,000	GASMAX	GASMAX3	.836(**)	0,003	GASMAX	GASMAX4	.999(**)	0,000

Table 9.

Test results DJ120.

Table 10).

In the table 10, there is a strong correlation between tests without additional weight and all the other vertical jump tests in Drop Jump 120.

DJ120	DJ1202			DJ120	DJ1203			DJ120	DJ1204		
NO ADDITIONAL WEIGHT	ADD 1/3 OF BODY WEIGHT	r	p	NO ADDITIONAL WEIGHT	ADD 1/2 OF BODY WEIGHT	r	p	NO ADDITIONAL WEIGHT	ADD 1/1 OF BODY WEIGHT	r	p
RFPRE	RFPRE2	.700(*)	0,024	RFPRE	RFPRE4	.962(**)	0,000	RFPRE	RFPRE3	.812(**)	0,004
RFACT	RFACT2	.830(**)	0,003	RFACT	RFACT4	.975(**)	0,000	RFACT	RFACT3	.849(**)	0,002
RFMAX	RFMAX2	.977(**)	0,000	RFMAX	RFMAX4	.977(**)	0,000	RFMAX	RFMAX3	.793(**)	0,006
BFPRE	BFPRE2	.720(*)	0,019	BFPRE	BFPRE4	.720(*)	0,019	BFPRE	BFPRE3	.963(**)	0,000
BFACT	BFACT2	.975(**)	0,000	BFACT	BFACT4	.793(**)	0,006	BFACT	BFACT3	.724(*)	0,018
BFMAX	BFMAX2	.863(**)	0,001	BFMAX	BFMAX4	.863(**)	0,001	BFMAX	BFMAX3	.797(**)	0,006
GASPRE	GASPRE2	.963(**)	0,000	GASPRE	GASPRE4	.798(**)	0,006	GASPRE	GASPRE3	.794(**)	0,006
GASACT	GASACT2	.724(*)	0,018	GASACT	GASACT4	.828(**)	0,003	GASACT	GASACT3	.830(**)	0,003
GASMAX	GASMAX2	.797(**)	0,006	GASMAX	GASMAX4	.974(**)	0,000	GASMAX	GASMAX3	.975(**)	0,000

Table 10.

Discussion

As mentioned above, our results showed a strong correlation between the variables selected for evaluation. Namely, myoelectrical activity of RF, the BF, and the GAS during preactivation, activation and the maximum value was found to have a strong correlation between the jumps made.

In the performance of SJ and CMJ high correlation in myoelectrical activity of BF, and the GAS was observed. During vertical jumps, DJ40 we witnessed high correlation in myoelectrical activity of BF and RF, while stronger correlations were found during the execution of the DJ and as increased drop height. Specifically, between the tests DJ80 DJ120 as we can see from the results, found a strong correlation in myoelectrical activity of muscle groups RF, the BF, GAS. This occurs because the long head of the biceps femoris were found to attain a peak in their activation level at the initiation of backward rotation of the upper body. The knee flexing moment produced by these muscles and the sub maximal activation of the knee extensors help to keep the net moment

about the knee, and therefore, the angular velocity increase rate of the of knee extension, low. As this maximum is approached, the activation level of the hamstrings drops and that of the knee extensors rises. The activation level of the plantar flexors remains sub maximal until the last part of the push-off. The sub maximal activation of the plantar flexors helps to keep the net moment about the ankle, and therewith the rate of increase in the angular velocity of plantar flexion, low. (Bobbert M. and Van Ingen Schenau, 1988)

Similar structures were used to facilitate the procedures when the drop height was large enough, (Galindo et al., 2009; Hoffrén et al., 2007; Sousa et al., 2007). This was performed not only when jumping with an extra large load, (Kubo et al., 2007; Comyns et al., 2007) but also when there was a large combination of drops and adding a large load in the execution of jumps (Horita et al., 1999). Even to avoid injuries in the performance jumps after fatigue protocols (Regueme et al., 2007; Kuitunen et al., 2007), jumps were performed with only one leg (Flanagan et al., 2007), and jumps in people during rehabilitation from injury (Flanagan et al., 2008). There are several reports in the literature relating to investigations in which we studied the jumping ability and muscle function in relation to the drop height and the use of additional weight (Gissis et al., 2003; Gissis et al., 2004), through various situations of jumps, in which we find the use of ramp construction. The purpose of this study was to examine the effect of the fall of the extra weight on selected parameters on the reactive capacity in sledge machines built for this purpose. In studies we can see that (Flanagan, E.P., Galvin, L., & Harrison, A.J. 2008) the relationship of strength and anthropometric characteristics of athletes jumping ability in volleyball, using specific vertical jumps and variations. Korff et al. (2009) used CMJ to evaluate the strength of the legs of different ages in children. The high activation of the muscles of the legs to support the first phase (eccentric phase) depends upon the production of elastic energy and greater muscle stiffness. Elastic energy is released in contraction, increasing strength in concentric phase. The muscular system shows to be prepared for large charges stretch, and naturally high muscle activity in the eccentric phase. It has been shown that myotatic reflexes increase by increasing stretching speed (Viitasalo, J.T, Salo, A., & Lahtinen, J., 1998). During the execution of consecutive jumps, the mechanical strength and the level of activation of soleus muscle is growing as the support time increases (Voigt, M., Simonsen, E. B., Dyhre-Poulsen, P. & Klausen, K., 1995). The stiffness of the lower extremities affects the transfer of elastic energy in a stretch - shortening cycle (Avela & Komi, 1998). The high activation of the muscles of the legs in the execution of vertical jumps creates changes in stiffness of the legs, while it increases the cause for the occurrence of peak vertical reaction forces (Zaggelidis G. & Lazaridis S., 2011),

Conclusion

In conclusion, the above method can be used as a reliable tool for assessing vertical jumps (drop jumps and rebound jumps) regarding the myoelectrical activity of the legs. In cases where this is not possible, the execution is of simple form. Furthermore, to prevent injury and due to a high level of difficulty, subjects can perform sessions of jumps in a seated position, ensuring the stability and the balance of the body including the joints of the hip, knee and ankle, and achieve safe jumps without risk of injury. This also facilitates setting the height of fall, setting the angle needed to perform the jump as well as adding extra weight.

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