EXAMENSARBETE | BACHELOR'S THESIS

Examining muscle activation for Hang Clean and three different TRX Power Exercises

A validation study

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Halmstad May 24th 2012

Abstract

Background: Resistance training has proven to increase athletic performance, traditionally barbell training and Olympic Lifting have been used for this purpose. Sling training has recently been developed as a complement or substitution to traditional resistance training. Research has shown an increase in sport specific athletic performance and core stability with sling training. TRX Suspension Trainer is a newly developed sling training tool and to date no independent research has been done with the TRX. **Purpose:** To examine and compare muscle activation using TRX and the Olympic Lifting movement Hang Clean. **Methods:** 32 senior high school male soccer players participated in the study. Surface electromyographic (sEMG) data were collected on mm.erector spinae (back), m.gluteus maximus (glutes), m.vastus lateralis (quadriceps), m.semitendinosus (hamstrings) and m.gastrocnemius caput laterale (calf). Surface EMG data was collected when the subjects performed five different exercises, Hang Clean, TRX Squat Jump, TRX Front Squat and TRX Power Pull. In addition a Squat Jump was used as reference. **Results:** A similar muscle activation was found between Hang Clean (674 µV), TRX Squat Jump (684 µV) and TRX Front Squat (691 µV). TRX Power Pull showed the highest activation for mm.erector spinae and m.gluteus maximus but the lowest when comparing total muscle activation for all measured muscles. **Conclusion:** The similar amount of muscular activation for Hang Clean, TRX Squat Jump and TRX Front Squat indicates that the TRX Suspension Trainer can be used as a complement, for experienced athletes, or a substitution, for novice athletes, to traditional strength training. Coaches and athletic trainers should acknowledge the need and the importance of resistance training for athletic performance.

Keywords: TRX, Hang Clean, Sling Training, EMG, Power Training.

Acknowledgements

The authors would like to thank John Bauer Senior High School soccer players and coaches for their participation throughout the study. The authors would also thank Charlotte Olsson, for great supervision and good advices, Stefan Ljung at Concept, for providing the TRX equipment, Idrottscentrum, for access to gym and Anna Staffansson for encouraging support.

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1. Background

1.1. Introduction

Strength training with free weights has in a multitude of studies proven effective for developing strength and power (1-5). Traditional strength training is usually done with dumbbells, barbells and free weight plates. These can be used for a multitude of exercises such as squat, deadlift, lunge, bench press, shoulder press and many others. Squat, deadlift and bench press are often called the big three base exercises (6). Hang Clean (see method for definition) is a common and well-studied exercise for this purpose (1-3). Hang Clean is often used by athletes who train in complex movements and power sports, for example soccer and handball. Equipment needed to perform Hang Clean is big, heavy and can be expensive. In later years, stability in strength training has been given a lot of focus and has led to development of new training equipment, such as sling training (7-13).

TRX® Suspension Trainer® (TRX) is a sling based training concept developed by Randy Hetrick, a former US Navy Seal. TRX makes it possible to work out in confined spaces and in the absence of a gym. The training concept is based on three different fundamental principles: vector-resistance, stability and pendulum. The vector-resistance principle gives opportunity to adjust resistance by angle to the ground, lever and gravity. The stability principle comes into play due to base of support and balance, and the pendulum principle due to the starting position in relation to the anchor point (8). To date no research has examined the effects of TRX training. Thus, the general purpose of the study was to examine if exercises performed with TRX can activate muscles involved, in power development, to a similar extent as the muscles involved in the Hang Clean exercise.

1.2. Background

Behind the performance of a complex movement lie a number of well-coordinated neuromuscular reactions. A neuromuscular reaction is either carried out by reflex, for example removing your hand if placed on a hot surface, or by voluntary movement, for example a squat or jumping. The central nervous system (CNS) and the peripheral nervous system (PNS) are involved in performing movements. Specifics of learnt movements is stored in cerebellum and used to conduct movements faster and better. CNS and PNS send signals to muscles about movements to be conducted. Muscles are divided in motor-units, these consist

of alpha-motor neuron and muscle fibers. The number of muscle fiber included depends on magnitude and precision of the movement (14). Humans have slow twitch muscle fibers, type I, and fast twitch muscle fibers, type II/type IIx. For jumping, sprinting and explosive movements mostly type II fibers will be activated and for longer, endurance activities mostly type I fibers are activated (15).

Power is the product of work over time. Work is the product of force and distance. Force is the sum of mass and acceleration. A movement with high power is a movement when a lot of work is done over a short period of time. High power can be explained either by moving a great load a certain distance in a short time or moving a lesser load further or faster. In power exercises a higher load can be used when acceleration is greater, for example in the power Hang Clean (15). Research has shown that increases in power is followed by increases in Electromyography (EMG) output (4). Electromyography and surface electromyography (sEMG) is commonly used (1, 4, 5, 9, 16-18) to examine the magnitude of neuromuscular activation. The development of sEMG can be traced back to the mid-1600s and since 1849 used to measure voluntary contraction in human muscles (19). Electromyography represents the measurement of sarcolemma action potentials with EMG providing a window into the nervous system (20). Generally, greater amplitude in EMG tracing comes from a greater muscular activation.

It is not possible to measure specific mechanisms in muscle activation with sEMG. It is important to take the neuromuscular learning into account when doing measurements with sEMG (15). With training, neurologic learning and optimal muscle activation increase, which will lead to increased force and power development. This will make it possible to perform the same exercise, with the same load and with less effort (15). Furthermore, differences in EMG activity can be seen between different muscle contractions, for example when doing an isometric contraction the relationship of muscle force and muscular activation is linear (21). A concentric contraction gives larger sEMG amplitude compared to eccentric contraction (19). Research suggest that there is a connection between the sEMG amplitude, a faster movement and a heavier weight (16), which means power. The relation between sEMG and power is also found in other studies looking at EMG in power lifters (4). There is also a strong correlation between the acceleration-time profile and the net muscle activation (20).

Balance and stability are very important parts of sports and athletic performance (7), being important both when performing sling training and strength training. Balance is defined as maintaining a position with no movement for a certain time (15). An individual with good stability have a greater possibility to develop force from extremities than a person with inferior stability (7). One of TRX's fundamental principles is to challenge balance to force the individual to work more with his/her stability (8). Core stability in athletes has in later years shown to influence performance. Training on gym balls has shown good results for core stability but not for sport specific performance (9). Studies with similar sling training equipment as the TRX, for example RedCord, have shown to increase strength, stability and sport specific performance, for example in handball, softball, soccer and golf (10-12, 22). Measurements with EMG were not done in these studies.

1.2.1 Definition of close kinetic chain and open kinetic chain exercises

A closed kinetic chain (CKC) exercise is an exercise where the proximal joint faces a considerable resistance which limits or prevents free motion, an example would be squats. An open kinetic chain (OKC) exercise is an exercise where the proximal joint unhindered can move freely in different directions, for example when performing Hang Cleans. This can be described as a closed or open path of movement (15). Research has shown better results in vertical jump and joint stability after training with CKC compared with OKC exercises (22). Earlier research with CKC sling training have shown similar development in strength and balance as traditional strength training with free weights, which is OKC (13). Sling training, compared to traditional strength training, has for example resulted in higher throwing velocity in female softball players (22). Different recruiting patterns and a greater muscular activation, in mm.quadriceps measured with EMG, has been found with CKC compared with OKC exercise. Moreover, CKC exercises may provide a better loading position for the knee due to a more central tracking of the patella (17).

1.2.2 Closed- and Open kinetic chain and stability

Research has found larger muscular activation when training with free weights (OKC) in regards to training in a smith machine (CKC), this suggests that lesser stability gives a greater muscular activation (5). No significant difference in muscular activation have been found in training on stable versus unstable surface, though difference has been seen between concentric- and isometric activation and for maximal voluntary contraction (MVC) when comparing training on stable or unstable surface (18). Sling training is defined as CKC and has shown great improvements in stability (22).

1.2.3 Olympic lifting

Olympic lifting (OL) is one of the most used training methods to develop speed, jumping and explosive strength in athletes. OL is mainly a combination of a Hang Clean and a Squat. A lot of studies have given OL credit to be the best method to develop these sport specific characteristics in adult athletes (1-3, 23) as well as in younger athletes (3). Plyometrics, power, speed and strength are skills which are found in many sports, these skills have clearly been improved using the strength training exercise Hang Clean (2, 3).

1.3. Purpose

The purpose of this study was to examine muscular activity, in mm.erector spinae, m.gluteus maximus, m.semitendinosus, m.vastus lateralis and m.gastrocnemius caput laterale, for Hang Clean and three different TRX Power Exercises, and compare magnitude of total muscle activation between the different exercises.

In addition, jump height, an important factor in soccer, was measured for Squat Jump and TRX Squat Jump and compared to each other and also between subjects with or without previous resistance training.

1.4. Research question

Can exercises performed with TRX activate muscles involved in power development to a similar extent as the Hang Clean exercise? Which exercise generates the highest total muscle activation? In addition, is there a difference in Squat Jump performed with or without TRX? Is there a difference in jump height for subjects with experience and no experience of resistance training?

2. Method

2.1. Test subject and pre-test training

All subjects where male high school students (age 16-19). Thirty two subjects were divided into smaller groups. Each group was invited to seven practice sessions during four weeks, a total of 21 training session were held. The pre-test training was done to allow time for neuromuscular adaptation before the test. To participate in the test each individual had to attend at least four training sessions and acquire a correct technique in the training methods. During each session the groups were divided into two smaller groups, 6-10 subjects, one group trained with TRX and the other group trained with Hang Clean, after 30 minutes they

changed training methods. Each training session was one hour and all subjects performed both methods, in a randomized order, each time.

Twenty eight subjects, age: 17.2±0.8years, length: 181.0±6.0cm, weight: 73.8±10.0kg fulfilled the requirements and participated in the test. Their experience of soccer was 10.8±2.2years (n=28), experience of other sports (athletics, floorball, handball, ice hockey, bandy, table tennis, martial arts and fencing) or resistance training was 4.8±3.3years (n=18). Informed and written consent were given by all subjects and their parents. The testing took place one week after the last training sessions due to school holiday.

2.1.1 Dropouts

One subject failed to acquire a good enough technique with the Hang Clean. One subject sustained a back injury, outside the study, and could not perform the exercises. Two subjects did not turn up for the test.

2.2. Preparations

Before the test each subject was informed about the test procedures and reminded of the exercises. The test leaders marked the area were electrodes were to be attached. The subjects shaved and disinfected this area under supervision of their soccer coach, who was well informed of the study procedures. Adhesive electrodes were used and attached to the body, two electrodes on the mid-belly of the muscle and one lateral from the first two as a reference. Cables were attached to the electrodes and connected to the Me6000T8 sEMG Recorder (Mega Electronics Ltd. Kuopio, Finland). Measured muscles were mm.erector spinae (back), m.gluteus maximus (glutes), m.vastus lateralis (quadriceps), m.semitendinosus (hamstrings) and m.gastrocnemius caput laterale (calf) (24). The Me6000T8 was kept in a belt that was placed around the waist of each subject. Me6000T8 was connected to a Dell Latitude D610 (Dell, Texas, USA) and sEMG measurements were transferred via cable. MegaWin 2.3 was used for recording and measuring EMG. EMG raw data was smoothed in MegaWin 2.3, calculating average EMG amplitude, peak values for each exercise was collected and written down. In order to compare results a reference needs to be set, for example a standardized exercise performed by all subjects.

2.3. Test

Each exercise was performed in three repetitions, sEMG was recorded and the peak value of each measurement was collected for analysis. All measurements were done on the subjects'

dominant leg, the leg they preferably used for kicking in soccer. First the subjects performed three Squat Jumps and jump height was measured. The Squat Jump (used as reference) was performed with hands on opposite shoulder from a steady position with 90º flexion in the knee joint. Jump height was noted in the test protocol and saved for analysis. Test order was randomized in advance. The TRX exercises (appendix 1) were performed with body weight and the Hang Clean (appendix 2) was performed with a 20 kilogram Training Barbell (Eleiko Sport, Halmstad). The TRX was adjusted to 126 cm from the anchor loop to the handles. The TRX anchor loop was hanging at 181 cm above the floor. The TRX was held under tension during all exercises.

TRX Squat Jump started with upper arms along the side of the body and a 90º flexion in the elbow. Jump height was registered for TRX Squat Jump, measured with an infra-red measuring system, IVAR Test Equipment (IVAR Testsystem, LN Sport Konsult HB, Mora, Sweden). While holding the TRX handles the subject did a squat and was told to stop at 90º flexion in the knee joint. From that position the subject jumped straight up, simultaneously pulling the TRX downwards.

TRX Front Squat started with the subjects hanging in the TRX handles, placed under the arms close to the armpits, facing the floor. Feet placed directly below the TRX anchor point. The subject did a squat movement to a tucked position followed by a full extension in the hip, knee and foot, resulting in a forward jump with a straight body. The landing took place about 20-80 centimeters forward and a return to starting position was made.

For the TRX Power Pull the handles were assembled to a one-hand grip. Feet were placed 140 centimeters away from the anchor point. The subject leaned back into a tucked, sitting position holding the TRX with one hand and the other hand stretched backwards touching the floor. From this position, primary, an explosive hip and leg extension took the subject to a standing position. Secondary a pulling motion with m.deltoideus and m.trapezius was made. The free arm was reaching towards the TRX anchor point in the standing position maintaining balance. The TRX Power Pull was performed twice, once with each hand holding the TRX. The measurements were done on the dominant leg and the results divided depending on which hand that hold the TRX. All TRX exercises are shown in appendix 1.

Hang Clean started with the barbell parallel to patella and finished with the barbell at m.deltoideus (shoulder) anterior part (23). The Hang Clean is performed with a small flexion in the knee joint and flexion in the hip, arms hanging straight down holding the barbell at shoulder width. The barbell is set in motion by extending the knees and hip in an explosive movement upwards at the same time the subject lands in a squat and catches the barbell on the anterior part of m.deltoideus and elbows pointing forward. Hang Clean is shown in appendix 2.

2.4. Surface electromyography

Surface electromyography (sEMG) has the advantage of no need to pierce the skin to obtain useful information about muscle activation. This method is harmless for the subjects and can be performed without interfering with ethics or personal integrity. EMG can give important information on muscle activation in certain movements and also give information about injuries or muscle activation not following normal patterns.

A few problems can arise when working with sEMG. There is a possibility of "cross-talk" in between muscles. Using well documented recommendations for electrode placement can help to eliminate this problem. Even faulty electrode placements can be avoided by evaluating documented recommendations. Another problem is muscle substitution pattern, when the neuromuscular system express a movement using different muscles than intended, for example a greater use of calf muscles than hamstrings to flex the knee (19). Muscle substitution patterns are avoided by giving time to familiarize with the equipment and exercises, to improve neurologic learning.

2.5. Statistical analysis

All values were reported as mean ±1 standard deviation (SD). Tables and figures were made using both Excel (Microsoft, 2007) and IBM SPSS Statistics 20. Statistical analyses were performed using IBM SPSS Statistics 20 for statistical analysis. Paired t-tests were used to compare total muscle activity between Hang Clean and each TRX exercises and to compare differences between Squat Jump exercises with and without TRX. Significance was set to $p<0.05$. Descriptive statistics were used to compare jump height between resistance and non resistance trained subjects. No statistical analysis was reported since only three subjects were in the resistance trained group.

3. Results

The Squat Jump the subjects performed was used as a reference for sEMG measurements (Reference Squat Jump) and resulted in the highest overall sEMG indications (721µV ±168), shown in figure 1.

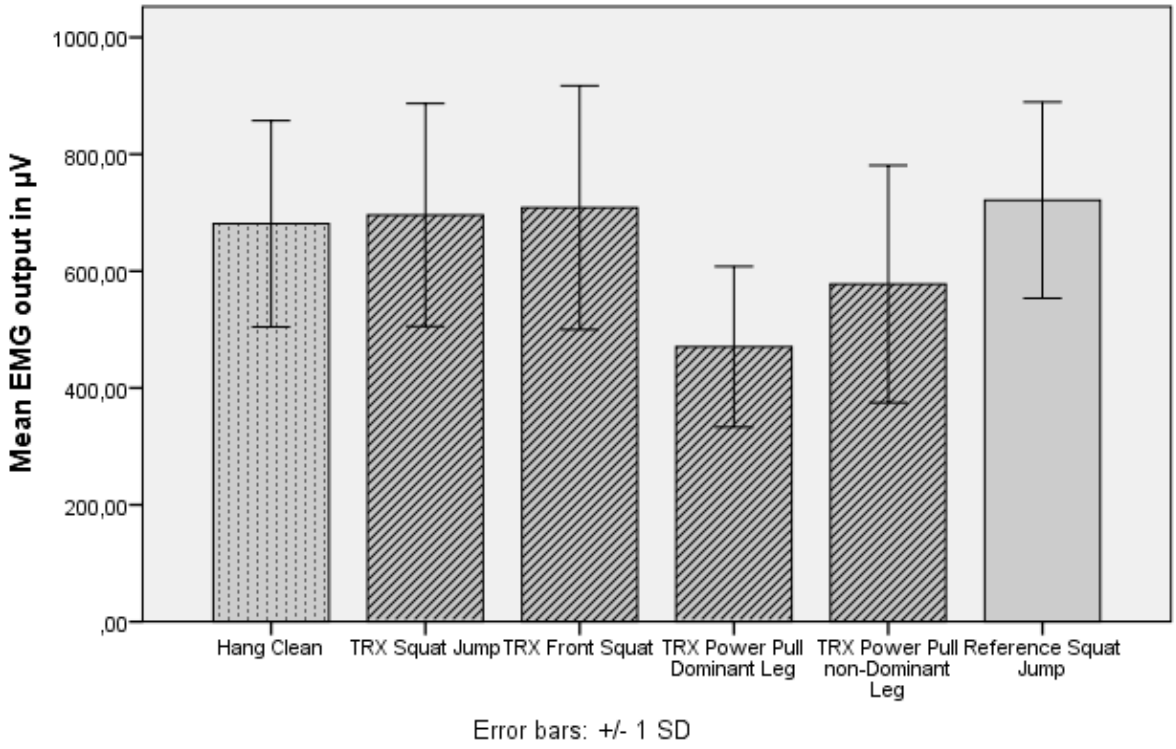

Figure 1 Mean (µV) total muscle activation for all five measured muscles together for each exercise (n=28). P-values for each exercise compared to Hang Clean (HC): HC vs. TRX Squat Jump p=0.645, HC vs. TRX Front Squat p=0.286, HC vs. TRX Power Pull Dominant Leg p<0.001, HC vs. TRX Power Pull non-Dominant Leg p=0.004 and Reference Squat Jump p=0.111.

Of interest in this study was to see if TRX exercises could result in similar muscle activation patterns as Hang Clean. No statistical difference in total muscle activation was found between Hang Clean and TRX Squat Jump (p=0,645) or Hang Clean and TRX Front Squat (p=0,286). As shown in figure 1, significant difference was found between Hang Clean and TRX Power Pull Dominant and non-Dominant Leg (p=0,001 and p=0,004). Hang Clean showed an even muscle activation for all measured muscles, it also generated the highest muscle activation for m.semitendinosus compared with the other exercises activation of m.semitendinosus. However, as seen in table 1, this high muscle activation also included a large standard deviation (624 µV±320). Both Hang Clean and most TRX exercises generated a high activation of m.gastrocnemius the exception being TRX Power Pull (table 1), m.gastrocnemius also showed the lowest standard deviation (<200µV) in all exercises.

Table 1. Mean sEMG values (in µV) ±1SD per exercise and muscle (n=28)						
Exercise / Muscle	Hang Clean	TRX Squat Jump	TRX Front Squat	Power Pull Dominant	Power Pull non-Dominant	Reference Squat Jump
Erector Spinae	675 ±247	689 ±202	665 ±296	731 ±269	651 ±263	695 ±240
Gluteus Maximus	680 ±463	697 ±460	771 ±588	273 ±208	823 ±651	730 ±414
Vastus Lateralis	774 ±315	912 ±357	1009 ±476	646 ±245	704 ±260	863 ±326
Semitendinosus	624 ±325	541 ±608	420 ±425	358 ±210	458 ±286	610 ±542
Gastrocnemius	652 ±187	641 ±169	678 ±173	345 ±161	253 ±148	709 ±200

In general, most leg exercises performed with TRX resulted in similar total muscular activation as Reference Squat Jump and Hang Clean. The TRX Power Pull showed the least total muscular activation (figure 1), but showed the highest activation in mm.erector spinae and m.gluteus maximus, as viewed in table 1. A big difference between dominant and non-dominant side was found in the TRX Power Pull (figure 1).

A significantly ($p<0.001$) higher jump height was measured when performing a TRX Squat Jump (38.6cm±6.3) compared to the reference Squat Jump (30.2cm±3.9) as shown in figure 2.

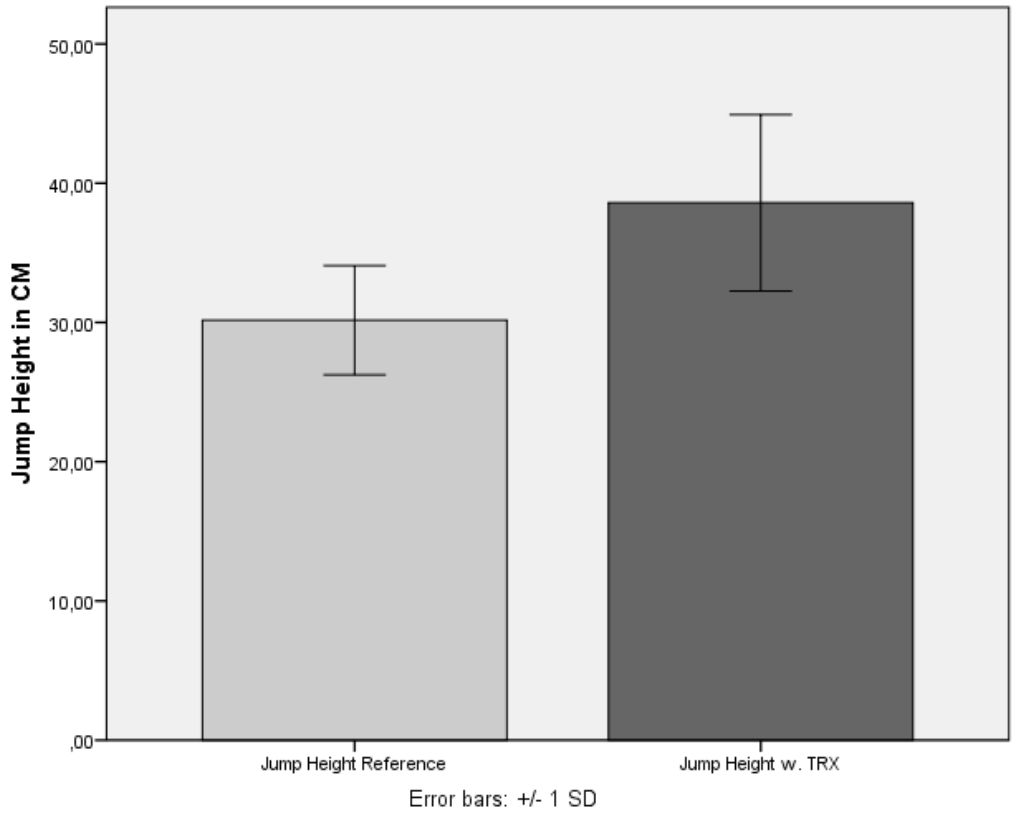

Figure 2: Mean (cm) jump height (±1 SD) for Reference Squat Jump and TRX Squat Jump (n=28). Significant at p<0.001.

When comparing jump height in Squat Jump between subjects with and without previous resistance training experience, a 4.8 cm difference in jump height was found. The same difference was 9.1 cm in the TRX Squat Jump. The experience group jumped 12.3 cm higher with the TRX compared to the no experience group who jumped 8 cm higher using the TRX, see table 2.

Table 2: Difference in jump height experience / no experience of resistance training.

	Experience resistance training	N	Mean	Standard Deviation
Jump Height Reference	No experience	25	29,6	3,6
	Experience	3	34,4	4,0
Jump Height w. TRX	No experience	25	37,6	5,9
	Experience	3	46,7	4,5

4. Discussion

The results from the present study showed similar total muscle activation for Hang Clean, TRX Squat Jump, TRX Front Squat and Reference Squat Jump, however, the total muscle activation for TRX Power Pull was lower compared to the other exercises. Jump height was greater in the TRX Squat Jump than the Reference Squat Jump and jump height was higher for subjects with resistance training experience compared to those with no experience of resistance training.

The Reference Squat Jump showed highest sEMG activation, which indicates that this was a well known exercise for the subjects where they could use their muscles optimally. All subjects had experience of soccer practice, generally soccer practice contains a lot of jumping which made Squat Jump a familiar exercise for the subjects' nervous system and in performance (15).

In this study we found a similar amount of total muscle activation for Hang Clean, TRX Squat Jump and TRX Front Squat. Over all Hang Clean, TRX Squat Jump and TRX Front Squat showed a similar activation for each muscle, with a greater difference in activation for m.vastus lateralis and m.semitendinosus. The result showed that m.semitendinosus was activated more in the Hang Clean and that m.vastus lateralis was activated more in the TRX exercises. An explanation for this could be the joint angles used in the different exercises. The similarity seen in the result indicates that these exercises can be used for the same purpose.

Some of the subjects had previously, but not regularly, tried Hang Clean. This could affect the neuromuscular adaptation and the results for these individuals. Hang Clean is a well known power exercise and the similar muscle activation for two of the TRX exercises compared to Hang Clean could tell us that these would be effective for power training too, which also has been shown in earlier research (4) where high EMG activation was associated with increase in power. In the mentioned study, the subjects performed squat jumps in a smith machine and the researchers measured EMG and peak power output. Our result could indicate that TRX is good for power training. Important to note when evaluating the results is that in the present study the weight used for Hang Clean was the same for all subjects, regardless of each subject's individual strength. A higher weight, closer to the subject's one repetition maximum, would very likely have given higher muscle activation. Some subjects might have been able to use a heavier weight, but some subjects were close to their one repetition

maximum (1RM) with the chosen weight. More time would have to be spent in training to establish each subject's 1RM for Hang Clean. The chosen weight is also closer to body weight as used for the TRX exercises. Our result could indicate that the examined TRX exercises can be good for increasing power. Power is commonly used in soccer and many other sports and an increase in power can be an increase in performance, which earlier studies with sling based training has shown. Research with red cord has shown an increase in kicking velocity in soccer, (10) club head speed in golf (11) and increased performance for softball players (22). Our results can not be directly compared with results from earlier research because the present study is the first one using sEMG and sling training.

A high activation and low standard deviation was found in m.gastrocnemius for all exercises except TRX Power Pull. This can probably be related to the subjects' soccer experience with a lot of time spent on the toes, with highly activated calves, when sprinting, jumping and moving.

The TRX Power Pull cannot be compared with Hang Clean in the lower extremity, but can be a good exercise for m.gluteus maximus and mm.erector spinae. In the TRX Power Pull the upper extremity is activated to a greater extent than in the other TRX exercises. Surface EMG measurements must be done on the upper extremity as well to confirm muscular activation. There is also a big difference between dominant and non-dominant side for the TRX Power Pull (figure 1).

In the present study a large difference was seen in jump height between Reference Squat Jump and TRX Squat Jump. Results also showed higher jump height for subjects with experience of resistance training. The difference in jump height might be explained by the fact that when performing a TRX jump squat upper body muscles are being used, resulting in a pulling motion and a higher jump. The higher jump height for subjects with experience of resistance training can be explained by better experience in developing power, as mentioned earlier (15). When analyzing jump height for subjects with resistance training experience they jumped higher both with and without the TRX compared to the no experience group (12.3 versus 8 cm). This indicates the importance of resistance training as a complement to soccer practice since jump height is one of the important qualifications in soccer (25).

4.1. Methods discussion

One thing that could have affected the result is how the sEMG equipment was used and the researchers' experience with the measuring method. To minimize problems a pilot study was done to acquire more knowledge and expertise, the pilot study was also performed to increase the reliability of the measurements. Researchers' attempted to avoid faulty electrode placement and cross-talk by double checking all electrode positions. Electrodes were placed over the mid-belly of the muscle by the researchers and the placements were reviewed (24). To avoid muscle substitution patterns all subjects participated in at least four training sessions with both methods to learn the correct neuromuscular pattern (19).

It would have been important to examine differences in the deeper stabilizing muscles in order to better examine the stabilizing effect of the TRX, unfortunately measurements of the deeper stabilizing muscles cannot be done with sEMG (15). The only muscle, examined in the current study, which has a stabilizing effect on the body, was mm.erector spinae. In addition to being a stabilizing muscle mm.erector spinae also has a large prime moving function in extension of the trunk. The deeper muscles of mm.erector spinae have the stabilizing effect on the body and the superficial muscles of mm.erector spinae have the prime moving function. With sEMG it is only possible to measure the superficial muscles (24). The stabilizing effect of mm.erector spinae would have been relevant to see for comparison of the two training methods and their effect on core stability and differences between CKC and OKC (13, 22). As mentioned before, earlier research has shown higher muscle activation for CKC exercises compared to OKC exercises (17, 22) and CKC exercise has shown an increase in stability (13). A small, but not significant, difference of this kind could be seen in the results. Increases in core stability have been seen in research with sling based equipment, but no EMG measurements have been done (12).

The weight chosen for the Hang Clean was done so because of a series of reasons. A lot of time would have been spent on training to guarantee a good enough technique in Hang Clean to allow subjects to train with a near 1RM load. There would also have been a great difference between each subject's 1RM, probably bigger than the difference in body weight as used in the TRX exercises. An alternative to use 20 kg would have been to use, for example, 50% of their body weight which would have been more comparable with the TRX but in four weeks they would not have been able to do this.

5. Conclusion

The results indicate that there is a similar amount of muscular activation for Hang Clean, TRX Squat Jump and TRX Front Squat. This means that the TRX Suspension Trainer can be used as a complement, for experienced athletes, or a substitution, for novice athletes, to traditional strength training, which also has been suggested in previous research, with other sling training equipment without sEMG measurements (10-12, 22). This study highlights the importance of resistance training for athletic performance. Now, independent research has been done with TRX Suspension Trainer, more research have to be done to establish the possibilities and effects of the TRX.

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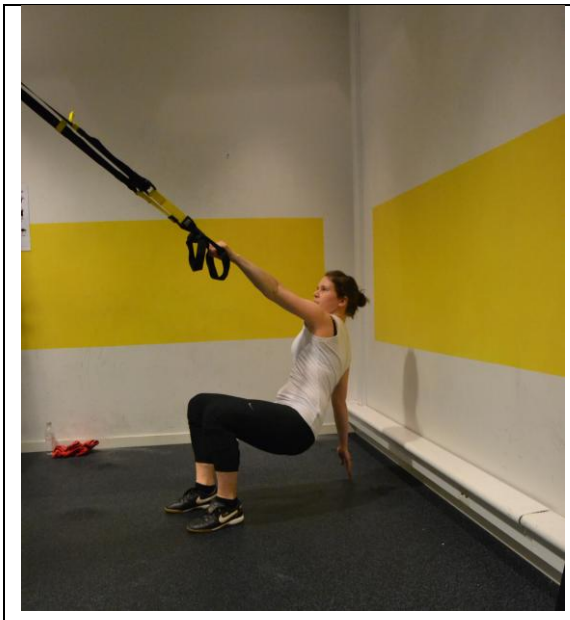
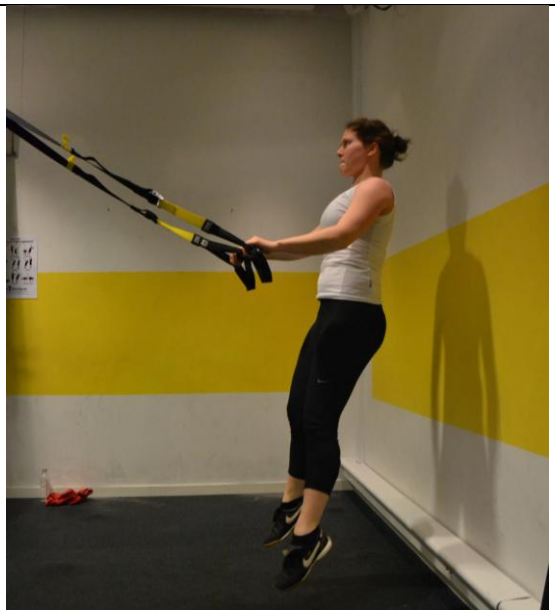
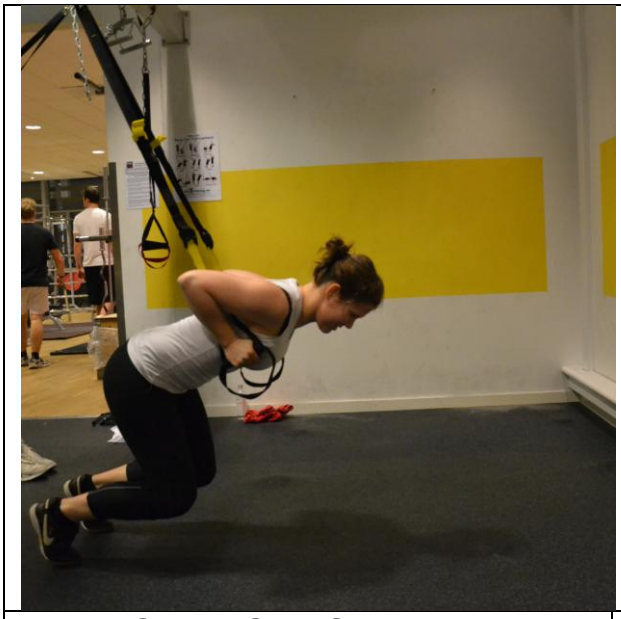
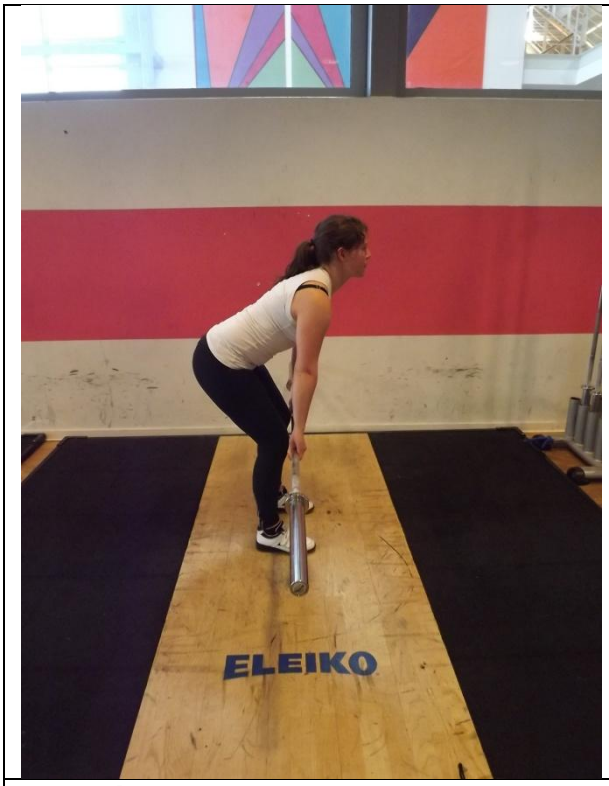
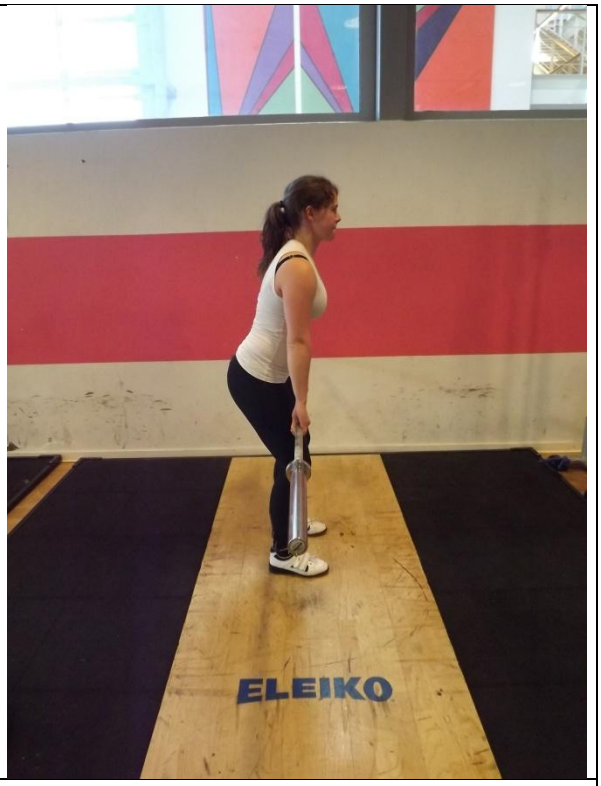
Appendix 1

	
Exercise 1: Power Pull Start Position	Exercise 1: Power Pull End Position
	
Exercise 2: Squat Jump Start Position	Exercise 2: Squat Jump End Position

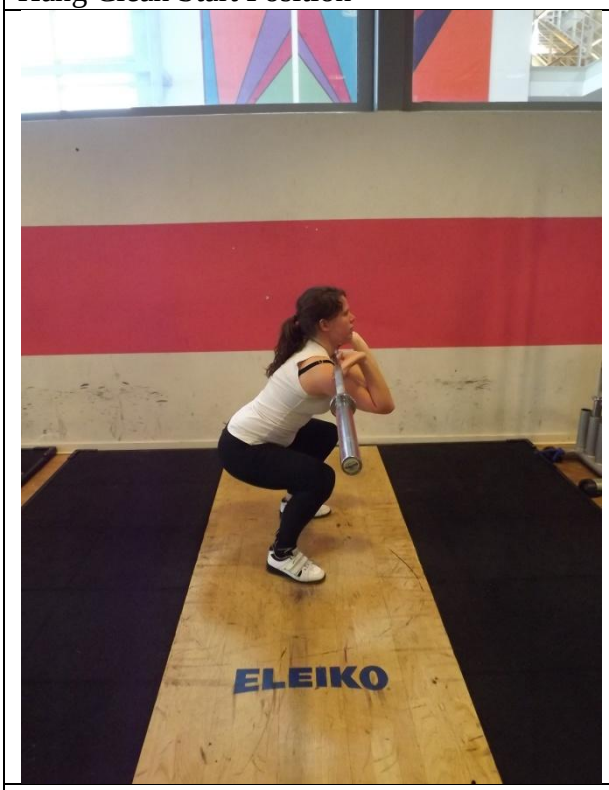
	
Exercise 3: Front Squat Start Position	Exercise 3: Front Squat End Position

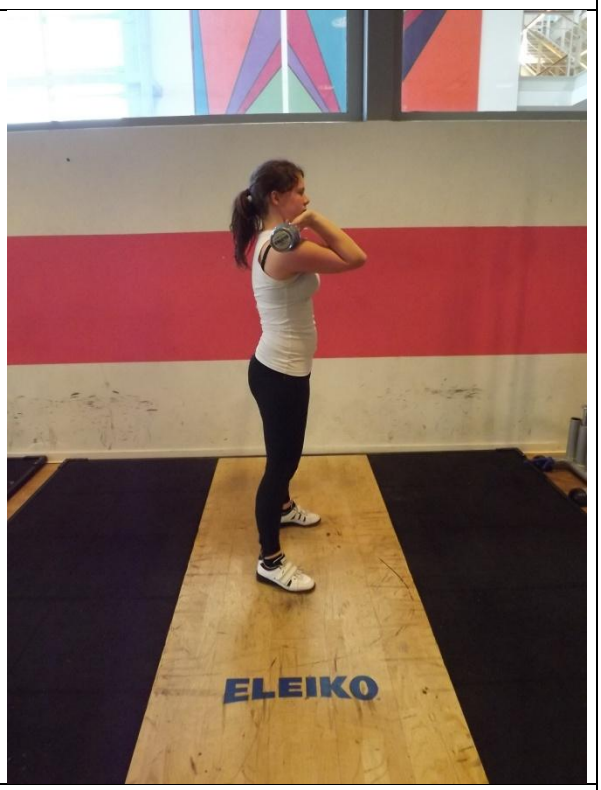
Appendix 2





Hang Clean Start Position





Hang Clean End Position