Bachelor thesis

Comparing of muscle activity during handstand and different core stability plank exercises and performance

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Abstract

The purpose was to measure and compare the muscle activation during the gymnastic element handstand and different static plank exercises. Twelve female elite gymnast (13.3 ± 3.7 years, 152.4 ± 8.7 cm, 40.5 ± 6.6 kg) participated in the study. The muscle activity of lower and upper rectus abdominis, oblique externus, erector spinae and gluteus maximus on the right side of the body was measured for all subjects (n=12) followed by calculation of the mean and standard deviation for the handstand and the static plank exercises. The result shows a similar EMG activity of the measured muscles during the plank exercises to the EMG activity during handstand. This suggest that these plank exercises can be used in a training program to create a stable platform for the gymnasts to control their body during handstand.

Key words: The Bunkie-test, handstand, gymnastics, core muscles, performance

Sammendrag

Hensikten med denne studien var å måle og sammenligne muskelaktiviteten i kjernen under turnelementet håndstående og fire forskjellige statiske plankeøvelser. Tolv elite turnere (13.3 ± 3.7 år, 152.4 ± 8.7 cm, 40.5 ± 6.6 kg) deltok i studien. Muskelaktiviteten i øvre og nedre del av rectus abdominis, oblique externus, erector spinae og gluteus maximus på høyre side av kroppen ble målt hos alle deltakerne (n=12). I etterkant ble gjennomsnittet og standardavviket regnet ut for håndstående og de statiske plankeøvelsene. Resultatene viser en lik EMG aktivitet av de målte musklene under plankeøvelsene til EMG aktiviteten under håndstående, det kan da konkluderes med at disse plankeøvelsene kan brukes til å danne en stabil plattform som er nødvendig i turn. Denne plattformen hjelper turnerne til å kontrollere koppen under de mange posisjonene de er igjennom, en posisjon som håndtstående.

Nøkkelord: Turning, plankeøvelser, the Bunkie-test, håndstående, kjernemusklatur, prestasjon

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1.0. Introduction

Muscles of the trunk and pelvis are referred to as the core musculature and these muscles are responsible for maintaining the stability of the spine and pelvis (Tse et al., 2005). The core muscles' ability to generate and maintain force is defined as core strength (Wilson et al., 2005; Zazulak, et al.,2007; Mendiguchia et al., 2011; Willardson, 2007), and core stability are the ability to control the position and motion of the trunk over the pelvis during both static and dynamic movements (Kibler et al., 2006; Zazulak, et al., 2007; Mendiguchia et al., 2011;Willardson, 2007).

1.1. Literature survey

If the muscles of the core are weak, or you are not able to activate and control them the performance in sports will loose its potential (Lilleheim, 2010). An important part of athletic development is core stability, however little is known about its direct relation to athletic performance (Reed et al., 2012). Tse et al. (2005) tested a core endurance exercise protocol. They found an improvement in core endurance, but did not improve performance in vertical jump, broad jump, shuttle run and 40 m sprint. Steffen et al. (2008) conducted a 10 week core training program, for female soccer players, which included 10 exercises. No significant improvements in jumping ability, 40 m sprint, or shooting distance were found after these training weeks. Santon et al (2004) tested and trained a group of high school athletes using a Swiss ball, a significant increase in core muscle strength were found, but in VO2max and running economy there were no improvements. On the other hand, Kim (2010) tested female professional golfers to investigate the effect of 12 weeks combined training in core muscle strengthening and driver shot performance (ball speed, clubhead speed and carry distance). The result showed that driver shot performance increased significantly within the training group. The clubhead speed increased from 38,77 m/s to 40,12 m/s, and the carry distance increased by 9 yards. Also, Saeterbakken et al. (2011) tested 24 female handball players, after 6 weeks with core stability training the testing group showed a significant increase in maximal throwing velocity with 4,9%.

1.1.1. The Bunkie-test

There are many developed tests and programs that has its meaning to test core strength or core stability, one of them is the Bunkie-test. It was developed to evaluate the kinetic chains along the linked connective tissue or fascia. The test consist of five plank positions and is repeated on the right and left side, each position is required to be held for 40 seconds (Pletzen & Venter, 2012). Bassett and Leach (2011) eliminated one of the plank position in order to have a neutral position during the hole test, hips, shoulders and ankles were in a straight line. Their subjects required to hold the positions up to maximum 20 seconds (Figure 1).

1.2. Gymnastics

According to Cleassens et al. (1999) are gymnasts among the strongest and most flexible of all athletes, this is because they have the ability to control bodily movement through a variety of positions. Willson et al. (2005) explains that it is the muscles of the trunk and pelvis that provides a stable platform, which helps to control these movements. Also, Kolba (2005) pointed out the importance of core stability training for gymnasts, because of all the different components of rotation and spin involved in gymnastics movements.

Bassett and Leach (2011) studied the effect of an eight week training program of core stability in junior female elite gymnasts. The results of the pre-test showed no significant difference between the training group and the control group, the difference after the post-test are likely due to the core training program. They concluded that core stability training is beneficial to gymnasts in relation to improving core endurance times up to 20 second intervals, which can be beneficial to performance in gymnastics.

1.3. Aim of research

There is a lack of literature which investigates if greater core strength and core stability actually improves athletic performance. In gymnastics there is different components of rotation and spin that the gymnasts goes through, the muscles of the trunk and pelvis provides the ability to control the body during these movements (Kolba, 2005; Willson et al., 2005). The aim of this study was to measure and compare muscle activity during the gymnastic element handstand and four static plank exercises. The handstand was also given a technique score by a gymnastics coach, and the acceleration in their hip and ankle was measured. It was hypothesized that there would be a similar muscle activity during handstand and the plank exercises.

2.0. Methods

2.1. Research Design

The presented work is a correlation study, in which muscle activation in the core during static plank exercises was compared with muscle activation in the gymnastic element handstand. There is a lack of literature which investigates if greater core strength and core stability actually improves athletic performance. To conduct this correlation study a test that evaluates the muscle activation in the core, displacement of the center of pressure, movement in the subjects' hips and ankles and a technique score was performed.

2.1.1. Subjects

12 female elite gymnasts (age: 13.3 ± 3.7 years, height: 152.4 ± 8.7 cm, mass: 40.5 ± 6.6 kg) participated in this study. They were selected from the local gymnastics club, where they train regularly 11,5 hours/week (mean). All subjects were able to perform handstand for at least 3 seconds. Before participating in the study, the subject and parents/guardians were informed about the testing protocol and an informed consent was signed. The agreement stated that the subjects could withdraw from the study if wanted.

2.2. Testing procedures

Prior testing, the subjects were introduced to the testing procedure including The Bunkie-tests' four static plank exercises (Figure 1) and the gymnastic element handstand. The subjects were given one try for each of the four static plank exercises and multiple tries for handstand. All of the static plank exercises needed to be held for 20 seconds to be counted. After the plank exercises a handstand was performed which had to be held for at least 3 seconds, where the best handstand was counted. Each electromyographic (EMG) and Accelerometers (Ergotest, Porsgrunn, Norway) were turned on and synced with the computer (Dell, USA). The 2D Force Plate (Ergotest, Porsgrunn, Norway) were placed on a solid straight ground and plugged to the computer.

Disposable electrode pads (EMG pads) were attached to the subjects' rectus abdominis, oblique externus, erector spinae lumbar region and gluteus maximus, right side of the body, before warm-up. Pads were fixed in muscle fiber direction, in order to monitor muscle activation. Following the regular warm-up routine of 20 minutes, the remaining electromyographic equipment (EMG) was installed. The number on the EMG-device attached to a muscle matched the number and muscle on the computer (example: EMG6 - gluteus maximus). Subjects performed a supine plank, prone plank, side plank and side plank 1-leg (Figure 1) in addition to handstand while muscle activation was monitored.

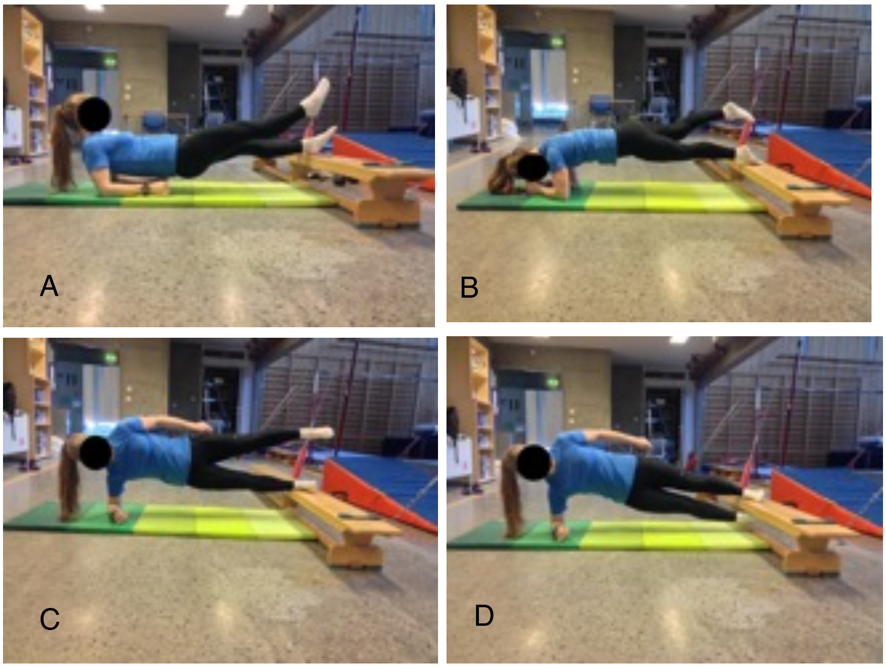

Figure 1: The Bunkie Test. A: Supine plank, B: Prone plank, C: Side plank and D: Side plank 1-leg

2.2.1. Displacement of the center of pressure and movement in hips and ankles

A 2D Force Plate (Ergotest, Prosgrunn, Norway) was used to evaluate displacement of the center of pressure during the handstand exercise. Accelerometers (Ergotest, Porsgrunn, Norway) were attached to the subjects' ankles and hips, in order to evaluate acceleration during the plank exercises and the handstand. The EMG measurement, force plate and accelerometers were all synchronized by a software program Musclelab 6000 (Ergotest, Porsgrunn, Norway).

2.2.2. Technique score

The handstands were judged and given a technique score by a gymnastics coach on a scale from 1-7. The technique score where evaluated out of three variables, bent legs, split legs and sway. The total scores were used for further analysis.

2.3. Data Analysis

All data were collected in the MuscleLab™ database directly, and the EMG to all muscles presented in RMS (root mean square), force plate sway left-right and back-forth presented in standard deviation, sum of hip and ankle acceleration presented in average, standard deviation and path were transferred into Microsoft Excel (2011, version 14.4.0). Mean and standard deviation was calculated and presented in charts. SPSS version 21 (IMB, statistic viewer) was used to make a pairwise comparison and are presented in tables. This shows the significant difference between each exercise.

3.0. Results

The primary aim of this study was to measure and compare the muscle activity during the gymnastic element handstand and static plank exercises. The muscle activity of lower and upper rectus abdominis, oblique externus, erector spinae and gluteus maximus was measured for all subjects (n=12) followed by calculation of the mean and standard deviation for the handstand and the plank exercises; supine plank (Figure 1, A), prone plank (Figure 1, B), side plank (Figure 1, C) and side plank-1 leg (Figure 1, D). The handstand were also given a technique score and the displacement of the center of pressure and acceleration in hip and ankle was measured.

3.1. Rectus abdominis

Results given in Figure 2 and 3 and shows a similar EMG activity of rectus abdominis (lower and upper) between the handstand and all the plank exercises with the right leg above or under the bench. Measures also shows a similar use of the lower and upper part of the muscle during handstand and the prone plank (B) and side plank (C) with left leg above the bench. There was a significant difference in EMG activity of lower and upper rectus abdominis between the handstand and supine plank (A) and side plank-1 leg (D) with the left leg above or under the bench (*).

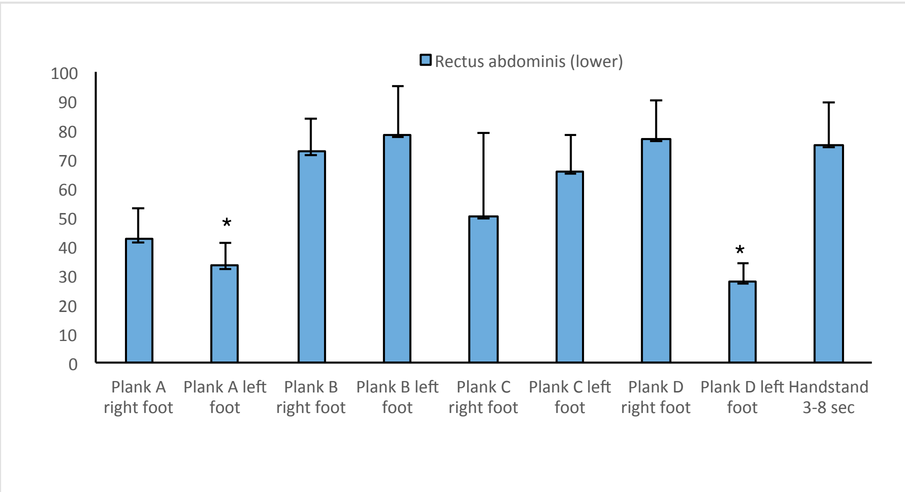

Figure 2: The figure shows mean and standard deviation of EMG activity of lower rectus abdominis in all the plank exercises and handstand, n=12.

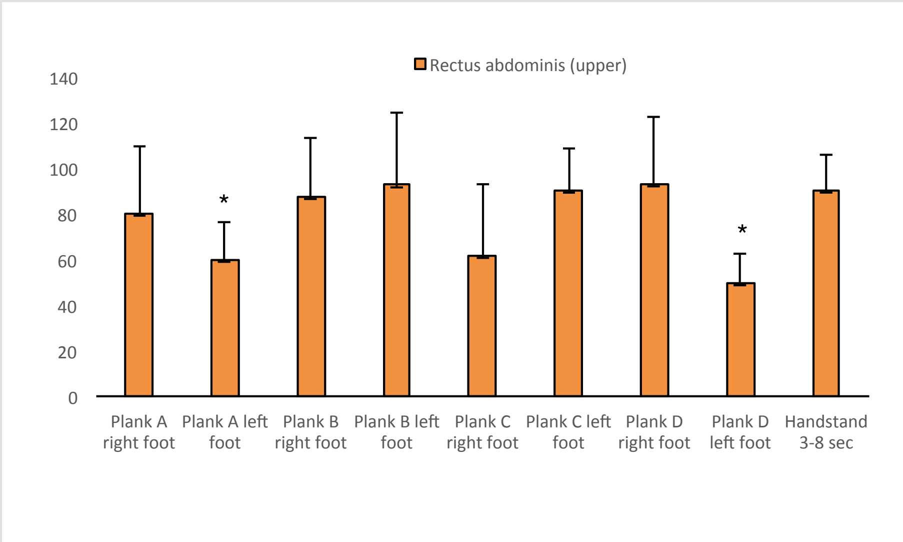

Figure 3: The figure shows mean and standard deviation of EMG activity of upper rectus abdomens in all the plank exercises and handstand, n=12.

3.2. Oblique externus

Figure 4 shows a similar EMG activity of oblique externus between the handstand and the prone plank (B) left and right leg, the side plank (C) left and right leg and the side plank-1 leg (D) right leg. A significant difference was observed by the EMG activity of oblique externus between the handstand and supine plank (A) left and right leg and the side plank 1-leg (D) left leg under the bench (*).

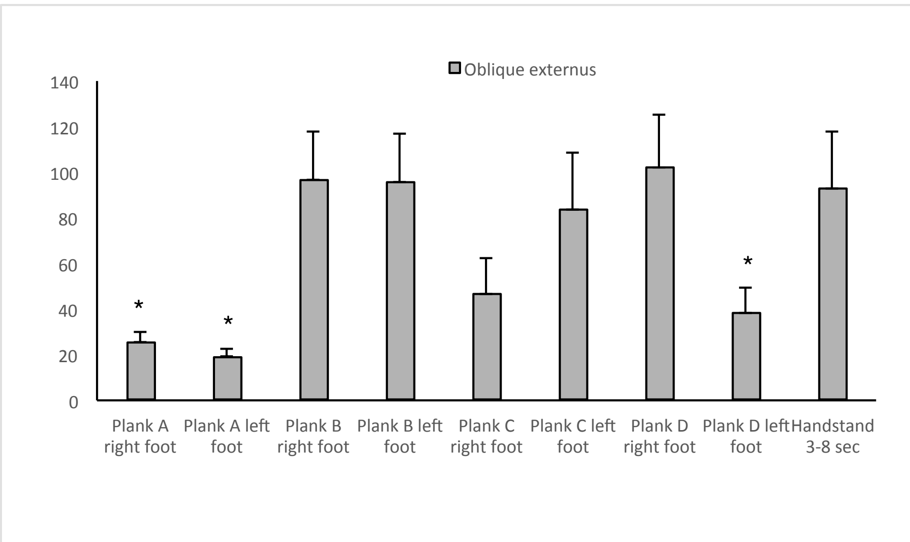

Figure 4: The figure shows mean and standard deviation of EMG activity of oblique externus in all the plank exercises and handstand, n=12.

3.3. Erector spinae

The measures presented in Figure 5 shows a significant difference in EMG activity of erector spinae between handstand and supine plank (A) right leg, prone plank (B) left and right leg and side plank-1 leg (D) left leg (*). There was no significant difference between the handstand and the other plank exercises.

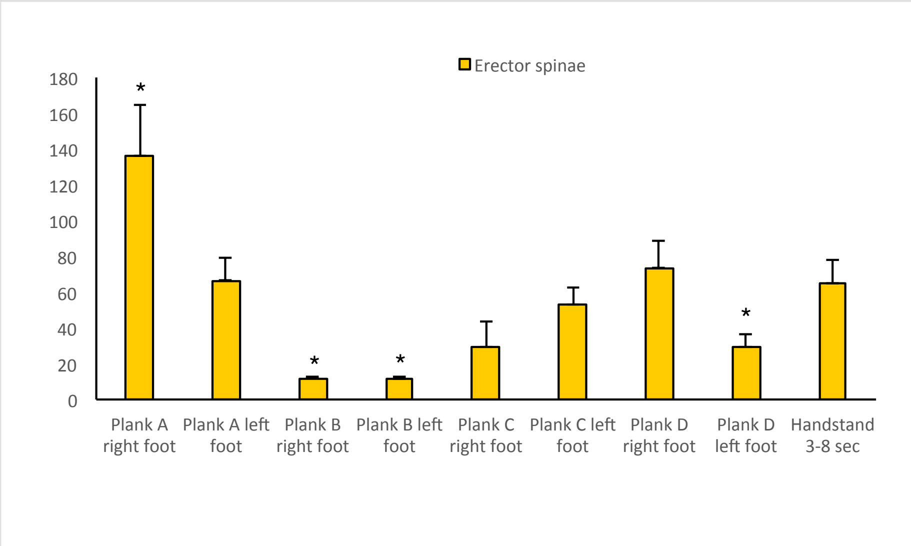

Figure 5: The figure shows mean and standard deviation of EMG activity of erector spinae in all the plank exercises and handstand, n=12.

3.4. Gluteus maximus

The gluteus maximus EMG activity was significantly different between the handstands and the supine plank (A) left leg, prone plank (B) left leg and side plank-1 leg (D) left leg (*). No significant differences between the handstand and the other exercises was discovered (Figure 6).

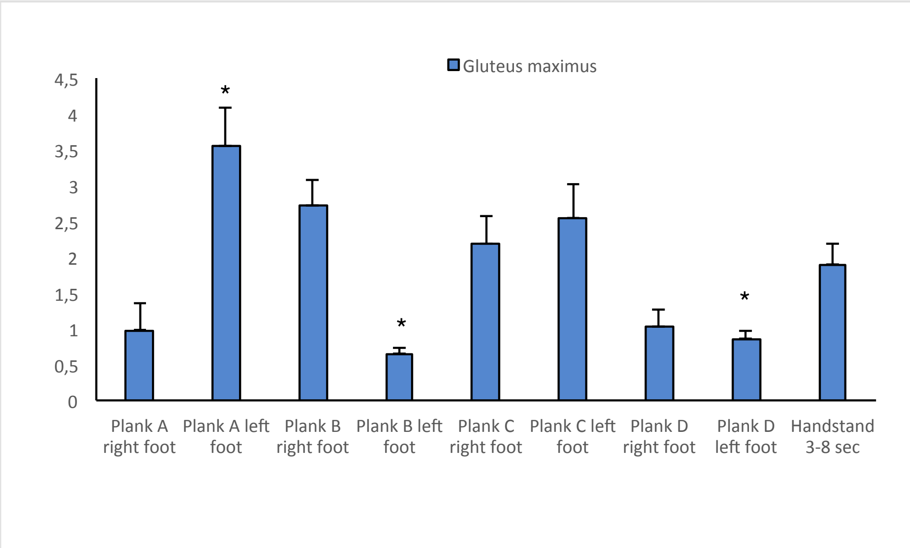

Figure 6: the figure shows mean and standard deviation of EMG activity of gluteus maximus in all the plank exercises and handstand, n=12.

3.5. Technique score

In Table 1 it was shown a significant correlation between the technique score and the use of gluteus maximus during handstand. The Table displays a correlation between the technique score and the sum of acceleration in the hip presented in standard deviation and the hips path during handstand. There was also a correlation to the sum of acceleration in the ankle presented in standard deviation and the ankles path during handstand (marked in green).

Table 1: Correlation between the factors measured during handstand and the technique score. N=12. ** correlation is significant at the 0.01 level, * correlation is significant at the 0.05 level.

	Handstand force plate sway left right	Handstand force plate sway back forth	Handstand rectus abdominis lower	Handstand rectus abdominis upper	Handstand oblique externus	Handstand erector spinae	Handstand gluteus maximus	Handstand hip acc average	Handstand hip acc stdev	Handstand hip acc path	Handstand ankle acc average	Handstand ankle acc stdev	Handstand ankle acc path	Technique score
Handstand force plate sway left right	1	−0,253	−0,224	−0,556	0,462	0,174	0,258	,833**	0,573	,799**	,849**	,774**	,810**	−0,497
Handstand force plate sway back forth	−0,253	1	0,331	0,089	0,395	−0,11	,643*	0,057	0,281	−0,003	−0,072	0,131	−0,075	−0,251
Handstand rectus abdominis lower	−0,224	0,331	1	,604*	0,14	−0,208	0,035	−0,04	0,079	−0,054	−0,217	−0,128	0,002	−0,353
Handstand rectus abdominis upper	−0,556	0,089	,604*	1	−0,136	−0,169	−0,288	−0,367	−0,325	−0,483	−0,469	−0,467	−0,431	0,058
Handstand oblique externus	0,462	0,395	0,14	−0,136	1	0,271	,705*	,577*	0,18	0,291	0,334	0,236	0,348	−0,54
Handstand erector spinae	0,174	−0,11	−0,208	−0,169	0,271	1	0,381	−0,141	0,014	0,19	0,086	0,076	0,035	−0,21
Handstand gluteus maximus	0,258	,643*	0,035	−0,288	,705*	0,381	1	0,331	0,426	0,42	0,212	0,393	0,361	-,585*
Handstand hip acc average	,833**	0,057	−0,04	−0,367	,577*	−0,141	0,331	1	0,494	0,547	,878**	,758**	,612*	−0,487
Handstand hip acc stdev	0,573	0,281	0,079	−0,325	0,18	0,014	0,426	0,494	1	,880**	0,512	,852**	,776**	-,698*
Handstand hip acc path	,799**	−0,003	−0,054	−0,483	0,291	0,19	0,42	0,547	,880**	1	,599*	,822**	,898**	-,677*
Handstand ankle acc average	,849**	−0,072	−0,217	−0,469	0,334	0,086	0,212	,878**	0,512	,599*	1	,868**	0,506	−0,373
Handstand ankle acc stdev	,774**	0,131	−0,128	−0,467	0,236	0,076	0,393	,758**	,852**	,822**	,868**	1	,691*	-,581*
Handstand ankle acc path	,810**	−0,075	0,002	−0,431	0,348	0,035	0,361	,612*	,776**	,898**	0,506	,691*	1	-,577*
Technique score	−0,497	−0,251	−0,353	0,058	−0,54	−0,21	-,585*	−0,487	-,698*	-,677*	−0,373	-,581*	-,577*	1

4.0. Discussion

Due to the lack of literature which investigate if greater core strength and core stability actually improves athletic performance, the propose to this study was to measure and compare muscle activity during four static plank exercises (Figure 1) and the gymnastic element handstand. The muscle activity in lower and upper part of rectus abdominis, oblique externus, erector spinae and gluteus maximus was measured for all subjects (n=12) followed by calculation of the mean and standard deviation for the handstand and the plank exercises; supine plank (Figure 1, A), prone plank (Figure 1, B), side plank (Figure 1, C) and side plank-1 leg (Figure 1, D). The handstand was given a technique score by a gymnastics coach, and the displacement of the center of pressure and the movement in the gymnast hip and ankle was measured.

4.1. Similar EMG activity

In gymnastics the gymnast goes through different of positions which needs to be controlled, their ability to control these bodily movement has demonstrated that gymnasts are among the most flexible and strongest of all athletes (Cleassens et al., 1999). The core makes a stable platform which help the gymnast control these bodily movements (Willson et al., 2005). The EMG activity in all of the measured muscles showed equality between the handstand and the side plank (Figure 1, C) both legs and the side plank-1 leg (Figure 1, D) right leg. This indicates that these plank exercises can be used in a training program to create that stable platform to help the gymnast control their body during handstand and all the elements that runs through handstand, such as back handspring. Also the relationship between the handstand and the prone plank (Figure 1, B) right leg has a EMG activity resemblance with all the measured muscles, but a significant difference for erector spinae. This might be because of a smaller of use of erector spinae during this plank exercise, as shown in the result we see a significant different EMG activity to the same plank (left leg) for erector spinae and gluteus maximus. The different EMG activity for gluteus maximus can be explained because of the left leg, which means that the left gluteus maximus is used, not the right that is measured here. Witt and Venter (2009) explained that the prone plank, original called the anterior power line, are recruiting the front line fascia which can explain the result of this study.

4.2. Significant different EMG activity

The result shows a significant different EMG activity for all the measured muscles between the handstand and the side plank-1 leg (Figure 1, D) left leg. Since the plank exercise with the right foot under the bench showed a similar EMG activity with all measured muscles to the handstand, can this indicate that the left side muscles is used when the plank exercise is performed with the left leg under the bench. Another significant different EMG activity to all measured muscles, expect erector spinae, between the handstand and the supine plank (Figure 1, A) left leg. Which can indicate that the left side of the muscles are used to hold the leg lifted, erector spinae is used to stabilize and keep the body above ground. The supine plank, original called posterior power line, uses the back line fascia (Witt and Venter, 2009). The supine plank right leg showed a similar EMG activity with upper and lower rectus abdominis and gluteus maximus, and there was a significant difference to oblique externus and erector spinae. This can indicate that the left side of erector spinae is used to stabilize when the right leg is lifted. Also the result imply that oblique externus is not used like it is used in a handstand.

4.3. Technique score

During a gymnastic competition the gymnast is evaluated by judges and is given a score for each apparatus. The final score, consists of a D-score (the content of an exercise) and a E-score (the execution and artistry) (FIG, 2013). In this thesis the technique score was given by a gymnastic coach on a scale on 1-7, were 7 is the best, the score were given to three factors (bent legs, split legs and sway) and the sum were calculated. The technique score showed a correlation to the EMG activity for gluteus maximus during handstand. This can imply that the EMG activity of the gluteus maximus are to stabilize the body during handstand, and therefore a better handstand. Kerwin and Trewartha (2001) concluded that the hip, and its muscles, is important to maintain a handstand. The technique score also showed a correlation to the sum of hip acceleration presented in standard deviation and the hip path during handstand. The result also showed a correlation to the sum of ankle acceleration presented in standard deviation and the ankle path during handstand. This indicates that the technique score and the acceleration measures (standard deviation and path) of hip and ankle are so similar that they confirm each other.

5.0. Conclusion

This study aimed to measure and compare the muscle activity during the gymnastic element handstand and four different static plank exercises (Figure 1). The muscle activity in lower and upper part of rectus abdominis, oblique externus, erector spinae and gluteus maximus was measured for all subjects (n=12) followed by calculation of the mean and standard deviation for the handstand and the plank exercise. The handstand was given a technique score by a gymnastics coach, and the displacement of center of pressure and the movement in the gymnast hip and ankle was measured. The result shows a similar EMG activity for the measures muscles during the plank exercises to the EMG activity during handstand, the significant differences is either due to use of the left side or a smaller use of the muscle.

In conclusion, all of the eight plank exercises (left and right leg) can be used in a training program to achieve the stable platform, which gymnasts need to control their body during handstand and gymnastics elements that runs through handstand.

For further research, it would be interesting to compare the technique score and the EMG activity to each handstand, where the results can show which muscle activity a good handstand requires.

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