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The effect of core stability warm-up on performance

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PREFACE

Many professionals use core stability exercises as part of warm-up programs. However currently there is no scientific consensus regarding the effectiveness of this approach. This inspired me to do further research about the topic. I learned during my education that not only individual clinical experience but even more the best available clinical evidence about a treatment makes an improved patient outcome possible. I wanted to execute a study, which could be useable for a wide range of people in different settings.

This paper is primarily addressed to health care professionals interested in or working with orthopaedic patients and athletes. It is the hope of the author that this research might spark further interest in this theme and further research is done about it.

Verena Mitterer

Eindhoven, 29th of May 2013

ABSTRACT

Background Information. Core stability has been described to be important for limb motion, since we move in a kinetic chain rather than in single segments during complex movements. Furthermore warm-up programs have shown to enhance coordination as well as performance. The combination of the two of them, in terms of core stability warm-up, is widely used in daily practice but has to the authors knowledge not been investigated scientifically so far.

Objective. The objective of the study was to determine if core stability warm-up has an effect on high-intensity interval endurance capacity.

Design. The study was designed as a randomized prospective study.

Method. The intervention group performed planking and a side bridging exercises combined with three minutes of fast walking. The control group performed fast walking for eight minutes. Performance was measured with the Yo-Yo Intermittent Recovery Test 1 and results were compared between control and intervention group.

Results. The measurements were performed on 22 recreational student athletes, randomized into intervention (eight male, four female; median age: 24 years) and control group (nine male, three female; median age: 26 years). No significant difference was found between the two groups.

Conclusion. Based on the results of this study, one could assume that there is no effect of core stability warm-up on performance. However, due to the many limitations of the study, neither rejection nor approval of the hypothesis is possible. Nevertheless, the possible positive effects of warm-up as well as of core stability exercises on performance, coordination, rehabilitation and injury prevention should be further researched.

Keywords. core stability; coordination; performance; warm-up

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INTRODUCTION

Over the last decades core stability (CS) has been a keyword within fitness and sports industries. Due to media claims, there appears to be an emphasis on CS for different kinds of training (1). Many sports clubs as well as trainers and therapists use programs which include CS exercises (2). Although the common use and the belief that CS is a crucial factor for performance of many sports, especially soccer, until today the correlation is not fully understood and scientific evidence is lacking (3,4).

One factor limiting research on this topic is that CS has suffered a wide range of definitions. Until today there is no official agreement on a standard definition of CS. For the purposes of this study the following definition was found the best suitable: CS is the ability to center and control the trunk over the pelvis. It makes it possible to move distally due to the proximal stability (5). A reason why CS is relevant for limb movement is a proximal to distal accurate and efficient running force production, transfer and control of motion (5,6).
This proximal to distal connection (force transfer within the kinetic chain) has also been shown in the study of Hodges et al. (7), which demonstrates that there is an anticipation of core muscle activity prior to muscle activities in the extremities.
Frank et al. (8) stated that during any complex movements like in athletic performance the body should rather be seen functioning as single unit than in multiple segments. Both, local and global synergistic coordination of various muscle groups are necessary for these complex movements (8). When the stability - , mobility - or balance function of these muscle groups is reduced, the efficient force transfer through the trunk to the extremities often gets affected adversely (8). Consequently, CS has become the focus of many training and conditioning program (8).
It is believed that optimizing force transfer within the kinetic chain and therefore energy economy (energy output in relation to input) could lead to a better performance. Energy economy has been stated to be a crucial factor for the overall distance performance, as in for example running (9).

The association between CS and athletic performance has been studied before. Sharrock et al. (10) found in their study this specific correlation between CS and athletic performance measures of their subjects.
Further, CS training has been shown to actually improve the athlete's running performance (11). Five exercises were, besides one, performed on a balance ball and executed five times per week for six weeks from the intervention group of the study of Sato et al. (11). The control group continued their normal training routine. The treatment group increased their running-time of a 5000m track significantly compared to controls.

Not only CS but as well warm-up has a very important biomechanical influence on coordination, movement and its efficiency. As shown by Brown et al. (12) active (10 minutes of running: 70% VO2max) as well as passive (hot water submersion) warm-up had a positive effect on performance in

terms of repeated sprinting ability (high-intensity intermittent running) compared to no warm-up as control. This shows that there is an acute effect of warm-up on high-intensive intermittent running.
Subasi et al. (13) attributed this effect to the possible biomechanical explanation that warm-up exercises diminish reaction as well as muscle response time and neuromuscular facilitation via increasing the sensitivity of joint position sense receptors, like muscle spindles (13). Muscles spindles are responsible for monitoring the amount of work that muscles need to perform and control the amount of contraction of muscles. The activation of these muscle spindles leads to fast and complete responses of the muscles and uses only the required number of fibrils (13). Therefore warm-up might safe energy, coordination and preparation of the nervous system is enhanced and injuries can be prevented as well as performance improved (13).
Furthermore Bishop stated that active warm-up might decrease initial oxygen deficit, postponing anaerobic taxing and thereby improve intermediate performance (14).

If it were possible to combine the 2 functions of warm-up and CS exercises this could lead to an ever more significant optimization of movements.

There is already existing evidence that not only training but as well warm-up programs like the FIFA 11+, which include among others, CS exercises, actually have an effect in terms of improving static and dynamic balance and therefore motor control (2). If these effects are partly due to the included CS exercises, and whether these effects can be transferred into performance improvement is not known.

Kaji et al. (15) found that there was an acute effect of two CS exercises (different kinds of planking) on postural sway while standing. Body sway was measured before and after the two exercises and compared. Results led to the conclusion that CS exercises had an influence on stability and could therefore be used as a warm-up program for athletes performing competitive sports, like handball, soccer, basketball etc., for which it is required to hold body sway to its minimal (15).

In comparison to the study of Kaji et al. (15), this study will try to look at the effect of CS warm-up directly on performance measured by the Yo-Yo Intermittent Recovery 1 (Yo-Yo IR1) test when compared to controls.
Kaji et al. (15) looked at CS exercise effects on postural sway whereas this study goes one step further trying to prove the theoretical knowledge stated above. If CS warm-up intervention would not only improve static balance but also coordination and therefore performance, it would be valuable for therapy and prevention as well as for sports. Another reason to investigate further is that Kaji et al. (15) looked only at static balance, whereas for the performance test of this study more dynamic balance is required. Dynamic balance is believed to relate more closely to sport-specific loading and is therefore more functional (16).

It is hypothesised that the CS warm-up will improve the performance of the subjects on the skills test when compared to controls. The test includes intensive running, quick turning and recovery for what it seems CS is an essential factor.

If activating CS via specific warm-up exercises leads to performance improvement, is not only of relevance for sports scientists and trainers but also for physiotherapists treating athletes wanting to go back to their sports-activities. It would be as well important for every other active treatment since it leads to the possibility of training more specific and coordinative for a longer time with less energy use. CS warm-up could optimize the movement system and be useful for pre-habilitation as well as for rehabilitation of athletic injuries and performance (8). An improved coordination as shown to be expected from warm-up (8) makes it applicable in rehabilitation, recovery from overuse injuries, and plays a role in return to athletic performance as well as in preventing sports injuries (8).

METHODS

Study design. The study was designed as a randomized prospective study and compared the performance on the Yo-Yo IR1 test of a group of subjects with CS warming up and a group with control warm-up beforehand.

Inclusion of subjects. All included subjects had to be between 18 and 30 years old. Both genders were included. A high-intensity sports performance of 1-20h per week was required. Subjects had to be unaffected by a respiratory, coronary, neurological or balance disorder and needed to be uninjured within the last two weeks. Subjects with a lower limb or back injury in the past two years were excluded.

Setting. On the 13th of February students of Fontys University of Applied Sciences were invited to participate in this study via e-mail. The e-mail included exclusion criteria (see Appendix I).
One week prior to testing all participating subjects signed the informed consent and filled out a questionnaire (see Appendix II and III). The subjects fulfilling all criteria received basic information on the testing, the video and instructions for the warm-up and Yo-Yo IR1 test to familiarize them with the procedure, via e-mail (Appendix IV). Both groups got these instructions since randomization was done later on and talking by the subjects about who got the CS exercises could have led to bias. The instructions were taken from the FIFA 11+ manual (17).

Procedure. Testing was performed in the Students Sport Centre (SSC) Eindhoven.
Standardized sentences were used throughout the testing, to exclude bias.
Two subjects were tested at the same time due to efficient time management. After the arrival and changing of clothes, the two subjects were randomized in intervention and control group, which was performed by drawing A or B. For this, stratified randomized controlling for gender was used.
Before the testing for this study could start, a number of other tests were performed due to the co-workers research. Those results are not presented in this thesis.
After the warm-up, the Y-Balance test was done (for the co-workers study), to test the actual effect of the warm-up on dynamic stability. This took maximal three minutes. Due to the availability of only one Y-Balance Kit, subjects from the intervention group had to wait the double amount of time. For more detailed information on the testing build up see table 1.
Thereafter the actual performance testing took place, the Yo-Yo IR1 testing.

table 1. Testing schedule

Time (min)	intervention group	control group
0 5	drawing lots and changing	drawing lots and changing
10 15	watching video explaining the Y balance test	waiting
20	Y balance test try-out	watching video explaining the Y balance test
25	waiting	
30	resting and leg length measurement	Y balance test try-out
35 40 45 50		resting and leg length measurement
55	stability baseline measurement	
60	*Warm-up CS*	stability baseline measurement
65		*Warm-up control*
70	stability measurement two	
75	waiting	stability measurement two
80 85 …	Yo-Yo IR1 and Y balance test measure three	Yo-Yo IR1 and Y balance test measure three

Waiting times; Co-workers measurement; measurement for this experiment

Intervention. The warm-up was different between the intervention and control group.

The intervention group performed three minutes of fast walking (6.7km/h, same as control group) on a treadmill. After that subjects performed three times 30 seconds of planking and three times 20 seconds of side-bridging (each side). Participants were excluded if they did not perform the exercises according to the instructions. The criteria used for measuring good performance were according to the manual of the FIFA 11+ (17). For the planking the body had to be in a straight line including head and feet and the elbows had to be placed just under the shoulders. The subjects were corrected if they would lift up their head, sway or arch the back or raise the hips. The side-bridge was performed with the lower arm and lower leg touching the floor. The upper leg was elevated. The subjects had to have the upper shoulder, hip and upper leg in one line, when seen from the front. From above the shoulders, the pelvis and both knees had to be aligned. The elbow had to be placed just under the shoulder. The participants were corrected if they tilted their head, pelvis or shoulders in any direction.

The exercises were performed alternately (planking – right side – left side – planking - ...). Breaks in between the exercises were of 10 seconds (for picture see Appendix V).

Many exercises are commonly used for core stability, but planking and side-bridging have been reported to be safe (18,19). This was another reason for the choice of these exercises.

The control group performed as control warm-up eight minutes of fast walking on a treadmill (6.7km/h). This speed was chosen due to the fact, that at this speed all subjects were still able to walk and did not have to run. That fact was important since walking has been shown to have no effect on performance as warm-up (20,21).

Performance measurements. The Yo-Yo IR1 test is to date the only internally and externally validated (22) and simple tool for monitoring aerobic fitness and registering changes in performance. It is a sensible tool to evaluate an individual's ability to perform intense intermittent exercise and recover from them, mirroring many common sports (soccer, basketball, etc.) (23). Krustrup et al. (22) have shown that the physiological responses during the Yo-Yo IR1 are comparable with those during a soccer match. As well the high intensity running during a match was correlated with the performance of the player at the Yo-Yo IR1 test. It was concluded that the test had a high reproducibility and sensitivity, making a detailed analysis of the physical capacity possible (22).
It has been shown that the Yo-Yo IR1 test is also a more sensitive tool to assess motor performance than maximal oxygen uptake (23).
Compared to the Yo-Yo IR2, the Yo-Yo IR1 is established for recreational athletes (24).

A distance of 20 meters was marked with two cones, succeeded by a five meters mark (see Appendix VI). The subjects initiated the test by running 20 meters, signalled by the first "beep" of the audio CD. At the next signal the return of the 20 meters distance had to be started. At the third beep the subjects started walking the 10 meters of active recovery. Every "beep" signalled the next departure. The speed of the signals increased with time, starting with 10km/h.
The level, at which the subject could not keep up with the speed anymore, was marked.
The heart rate (HR) was measured at this point to see potential inter-subject difference in cardiovascular loading. This was chosen to do due to the statement of Alexandre et al. (25) that HR has similar responses in high-intensity interval training as in soccer match play.

Data Collection. Data was collected by the two researchers and filled in a premade scheme. It was entered in a secured laptop. The same was performed with the anthropometric data.

Statistical analyses of the data. The performance (level) data was analysed with SPSS (Statistical Product and Service Solutions) and shown in a histogram for each group (intervention and control group, see paragraph "Intervention"). The graphs were classified into normally distributed or not by visual inspection.
Due to the histogram (Appendix VII) being non-parametric, the Mann-Whitney-U Test was chosen. The median and interquartile ranges of the performance of the CS warm-up group and the control group were compared to see if CS warm-up had an influence on the performance.
To determine the significance, the Exact p-value was used due to a small sample size.
In this experiment a α of 0.05 and a two tailed significance was used.

Ethics. The participants were asked to sign an informed consent (Appendix III). In this letter the subjects were informed about what would happen during the testing. It also displayed risks, which included possible fatigue and muscle soreness. Acute and long term problems were estimated as minimal. For safety reasons at least one researcher always accompanied each participant for the whole duration of the testing.

The data was collected and evaluated on two secured laptops. It is not possible to retrieve personal data from the report. With handing in the current report, the involved data and the intellectual property rights and claims was handed over to Fontys University of Applied Sciences, who committed itself to a confidentiality statement. The conveyance of rights agreement and the confidentiality statement can be found in Appendix IX and X.

Ethical approval was given by the signed consent of the project plan by the local ethics committee. (Appendix VIII)

RESULTS

All subjects meeting the inclusion criteria were included in the study, which led to number of 24 participants (N = 24). Two subjects were excluded from the study due to unfavorable environmental conditions, in terms of a very busy environment, making it impossible to hear the signals of the audio test. Therefore the total number of participants was 22 at the end. 11 subjects were randomly placed in the intervention group and 11 in the control. There was a percentage of 68.18% (n= 15) male and 31.82% (n=7) female participants in total. The intervention group consisted of eight (66.67%) male and four (33.33%) female subjects. The control group was constituted of nine (75 %) male and three (25%) female. The sports that were most commonly filled out by the subjects were jogging (intervention n=7 vs. control n=6), weight training (intervention n=5 vs. control n=6), biking (intervention n=4 vs. control n=2), swimming (intervention n=3 vs. control n=0), climbing (intervention n=0 vs. control n=3) and endurance training using cross trainers (intervention n=0 vs. control n=2). There was no statistical significant difference between the anthropometric measures of the two groups. The age of the population of the intervention group was on average 24 (23-25) years while the control group had a median age of 26 (24-28). For further details see table 2.

table 2. Demographic values (n=22)

	Median (IQR[a])		**Exact p-value***
	Intervention (n=11)	Control (n=11)	
Age of subject [y]	24 (23-25)	26 (24-28)	0.078
Sport [h/week]	6 (3.5-7)	6.5 (3-10)	1.000
Intensity of sport on scale (1-20)	13 (13-15)	14 (12-16.5)	0.319
Leg length [cm]	95.25(89-96.5)	92.00(89.5-98)	0.755

*Tested with Mann-Whitney U Test between intervention and control population
[a] Interquartile range

The raw results of the Yo-Yo IR1 were displayed in histograms in SPSS and analyzed. They were found to be not normally distributed. The graphs are displayed in Appendix VII.
The Mann-Whitney U Test was used to compare medians and ranges (IQR's) of the two groups.

As shown in table 3 there is no statistical significant difference between the CS warm-up and the control group on the performance of the Yo-Yo IR1 test.

table 3. Results of Yo-Yo IR1 testing (n=22)

	Median (IQR[a])	**Between group difference (Exact p-value*)**
Intervention (n=11)	12 (9-18)	0.133
Control (n=11)	10 (7-13)	

*Tested with Mann-Whitney U Test between intervention and control population
[a] Interquartile range

To estimate the difference in the cardiovascular load after the skill test the heart rate was compared between the two groups. Table 4 shows there was no significant difference between the intervention and control group at the level of cardiovascular load after the Yo-Yo IR1 in terms of heart rate.

table 4. Cardiovascular load after Yo-Yo IR1 (n=22)

	Median (IQR[a])		**Between group difference (Exact p-value*)**
	Intervention (n=11)	Control (n=11)	
Heart rate after Yo-Yo IR1 [bpm]	180(178-188)	180(173-180)	0.243

*Tested with Mann-Whitney U Test between intervention and control population
[a] Interquartile range

DISCUSSION

The purpose of this study was to determine whether CS warm-up increases performance measured with the Yo-Yo IR1 in comparison to control warm-up of eight minutes fast walking.

From the results it can be concluded that there are no statistically significant differences between the CS warm-up and the control group concerning performance on the Yo-Yo IR1 test.
Since the outcome shows an Exact p-value > 0.05 the hypothesis has to be rejected as the findings do not support it.

Furthermore, it seems that this study could not give scientific evidence for the widely used CS exercises of planking and side-bridging as warm-up. While warm-up programs like the FIFA 11+ have been shown to improve dynamic stability (2), this is not likely to be influenced by CS exercise part in them, since co-worker Miribung *(2013, unpublished data)* could not find significantly improved dynamic stability by using only the CS exercises of the whole program. Even though this effect was not confirmed, the possibility of improved performance was still possible, since as well Sato et al. did not find improvements in dynamic stability on the star excursion balance test (SEBT) but did find an increase in running performance (11). However this study failed to prove the findings from Sato et al. (11). This leads to the possible conclusion that the CS exercises (type and duration), population or performance test used in this study might not have been as optimal as in the study of Sato et al. (11). Another possible explanation for the non-significant results could be that there is no correlation between CS and performance at all and the authors of Sato et al. might just have been lucky with their findings (11).

Even though no studies look directly at the acute effect of the widely used CS warm-up, several studies tried to describe the correlation between CS and athletic performance before (3). However as shown below, until today contradictive findings are available in literature.
In line with this study, Tse et al. (1) found no correlation between an eight-week CS program and performance tests, like a 10m shuttle run in college aged rowers. However it is difficult to compare this study to the one of Tse et al. (1) since the authors did not state the exact CS exercises they used.
Conversely to the findings of Tse et al. and this study, as mentioned before, a study of Sato et al. (11) did find a relationship in CS training and a 5000m run when compared to controls. The five exercises used, besides one, were performed on a balance ball and executed five times per week (11). A difference between this study and the one from Sato et al. (11) was the type of running, which could suggest that CS exercises might be more applicable for endurance athletes instead of high intensity intermittent-runners.
The subjects in this study did different sports and most of them not intensive intermittent running which is being tested with the Yo-Yo IR1 test. However it was not possible to specify in the exclusion criteria of the subjects on sports-specificity due to the small sample availability of participants. When

comparing to the study by Sato et al. (11) (participants were all long distance runners) the performance test used in this study was less sport – specific.
Another possible explanation why Sato et al. (11) did find an effect and this study did not might be that there is an effect of CS training but not of warm-up. It could be assumed that there is a learning effect that might take a longer time to present itself, or that the running performance was related to core strength, that cannot be immediately improved by CS warm-up.
Similar to this study Sato et al. (11) was testing a very small sample size of only 28 healthy subjects.

The study of Sato et al. (11) might indicate that exercises on a balance ball are more effective for CS than planking and side-bridging, leading to a better athletic performance.
However, a number of studies tried specifically to prove this effectiveness with conflicting outcome.
Yaggie et al. (26) did a study of a four-week CS program on a BOSU balance trainer and showed a significant improvement of the subjects of the treatment group in balance, measured by time of standing on BOSU ball, as well as in shuttle run time. Comparing this study to the one from Yaggie et al. (26) the shuttle run course was of a different nature. Yaggie et al. (26) used a shorter run, had much more turns as well as side and backwards running episodes, for which CS might be of bigger relevance as for the Yo-Yo IR1. Another difference between the two studies is that Yaggie et al. (26) used repeated measures, making the outcome more reliable.

Nevertheless studies by Stanton et al. (27) and Scibek et al. (28), looked specifically at Swiss ball as CS training and found no improvement in running economy, running posture or swimming performance. However these studies did find a strengthening effect of Swiss ball training on CS itself compared to controls. Conversely to these findings the study of the co-worker Miribung *(2013, unpublished data)* did not find an improvement or CS itself after the intervention. Scibek et al. (28) and Stanton et al. (27) measured CS via the Sahrmann core stability test, the Swiss Ball prone stabilisation core stability test while this study used the Y-balance test. One of the measurement tools was very specific seeing that measurement as well as the training was done on a Swiss Ball. Maybe with another test the outcome would be different.
The authors of the studies by Stanton et al. (27) and Scibek et al. (28) suggested that CS exercises used in a more function -, position - and timing specific way for running, like single leg support and standing position, may lead to an enhanced running performance.

Other authors tried as well to find a connection between CS and performance in terms of measuring both.
On the one hand Okada et al. (6) concluded that there was no correlation between core strength and dynamic movements (backwards medicine ball throw for total body power, t-run agility test for agility and speed and single leg squat for muscle endurance of the lower limb) in the Functional Movement Screen. All the tests for core strength were static tests, whereas the performance tests were dynamic. Just as in this study the outcome by Okada et al. was not found to be significant and all the exercises/tests used for core strength were of static nature, whereas the performance tests of both

studies were of dynamic nature. This emphasises the importance of the functionality of CS exercises used. However, different to this study, the study from Okada et al. (6) and the following one measured only core strength and not core stability, which involves not only core strength but also motor control and proprioception (5).

On the other hand Nesser at al. (29) found a mild to moderate correlation when looking at core strength measures and comparing them with functional tests like the shuttle run, suggesting a potential weak relationship. A limitation of the co-worker's *(Miribung, 2013, unpublished)* the previous (6) and the study of Nesser et al. (29) might have been that there is yet no standard testing procedure for core strength. Therefore it might have been that important core muscles working in specific performance like the shuttle run were not tested in the right way or not tested at all.

Shinkle et al. (30), however, found in their study that core strength measures (static and dynamic medicine ball throws in different directions) were strongly correlated with performance measure like push press power, 1 RM squat, 1 RM bench press, countermovement vertical and broad jump. All of these performance tests were aimed at exclusively strength and not at aerobic high intensity performance in general, like this study did.

Surprisingly when looking at strength and upper extremity performance, another two studies (10,31) did find a significant difference conversely to their findings of lower limb performance. Sharrock et al. (10) as well as Saeterbakken et al. (31) noted that there was a relation between core strength and upper extremity performance. Six unstable closed kinetic chain exercises increased the throwing speed of female handball players (31). Sharrock et at. (10) measured core strength with a double leg lowering test. Comparing it with a medicine ball throw they found a significant correlation, even though this was not found for the correlation with a "40yd dash", agility run or vertical jump. This might lead to the conclusion that core strength is of more importance for upper extremity activity than for lower. Another explanation could be that the kind of movement could have an influence on the outcome. Open chain skills like a throw might require more proximal stability plus coordination and therefore CS might be of more importance.

A third explanation could be that the CS warm-up programs might have an influence on strength tasks but not on high-intensity endurance tasks. This can be explained by the principal of postactivation potentiaton (PAP). PAP is the effect of a maximum voluntary contraction (similar to the planking exercise in this study) leading to an increased phosphorylation (more phosphate for the production of ATP) of myosin regulating light chains, which makes actin and myosin more responsive to Ca^{2+} (32). This leads at the end to an increased force production (33) and faster contraction (34). However, a study of Macintosh et al. (35) showed that the effect of PAP diminishes after four to six minutes and is therefore not enhancing performance more than five minutes after warm-up. Due to this, performance, measured with a 1 RM or other strength tests, might have more significant outcome than when measured with a high-intensity intermittent endurance test, because of the difference in test duration.

The variety of studies mentioned shows us that until now there is not a clear answer to the question if there is actually a valid and significant relationship between CS and athletic performance (3).

As in the above mentioned studies (6,10,11,26–31) the CS warm-up exercises used in this study were of a non-functional nature for intermittent running. A more significant outcome might be expected if the exercises were more functional for the Yo-Yo IR1. This hypothesis is reinforced by Martuscello et al. (36) who found ground based free weight exercises, like squats, deadlifts and overhead presses to produce larger activation of core musculature then traditional CS exercises.
Especially Hibbs et al. (37) argue with the principle of specificity and states that a clearer understanding of the role of specific muscles during CS activity could enable researchers to test CS in a more accurate way and build up more functional exercises. They suggest this could lead to a more effective transfer of these skills into actual sports performance.

This means that actually the control group had a more functional, even if not in terms of CS, warm-up than the intervention group. It might have equalised the effect of the intervention, since walking is more similar to running than planking; nevertheless, the intervention group performed as well a period of walking as part of their warm-up. On the one hand, the study from Binnie et al. (38) showed that a more functional warm-up does not have a bigger effect than a non-functional or no warm-up at all for swimming performance and triathlon. Other studies reported that fast walking does not affect performance (20,21). This defends that our control's performance did not benefit from their warm-up.

On the other hand Brown et al. (12) did find an acute effect of warm-up on performance. They showed that active (running on a 70% VO2max) as well as passive (hot water submersion) warm-up did improve repeated sprinting ability (high-intensity intermittent running using non-motorized treadmill ergometry) compared to no treatment at all (12). Seeing this there is the possibility that the outcome of our study was limited because it is likely that both groups experienced an effect of their warm-up. Maybe our study would have found a significant difference when compared with a no warm-up group. Due to patient safety reasons it was chosen to warm up both groups.
However the study of Brown et al. (12) shows us that there is an acute effect of warm-up in general on high-intensity running performance, like we suggested in our study.

Even though it might have been better to use a more functional warm-up program (37), the authors of this study decided different, due to the theoretical rationale presented in the introduction. To date frequently used warm-up programs incorporate static CS exercises. It was the goal of this study to find out if the positive effect found by other researchers (39) was influenced by the CS exercises or if it was due to other components of their programs.

Soligard et al. (39) found that a comprehensive warm-up program, the FIFA 11+, could prevent injuries in female soccer players. As well Daneshjoo et al. (2) found that the FIFA 11+ improved proprioception (measured with joint position sense) as well as static and dynamic balance (stork test and star balance

test) in professional male soccer players. According to these findings and the statements of Subasi et al. (13), that warm-up programs facilitate energy saving, coordination and can prevent injury via activating muscle spindles, it was hypothesised that performance would increase as well. Another reason why exactly this warm-up program was chosen was due to the co-operation with another study looking at the effects of CS warm-up on dynamic knee stability.

Unfortunately many common CS programs to date are of a static, non-functional nature, which might be a very big limitation in its effectiveness, as suggested by previously mentioned authors (37). In accordance to their findings this study did not find an effect of the non-functional planking and side planking on intermittent intensive running performance.
The effective, on injury prevention, shown FIFA 11+ exercises (39) implicates a whole battery of exercises, including CS but also balance -, eccentric hamstring strength, dynamic stabilisation and running exercises, making it a very functional approach at the end.
This leads to the conclusion that the effectiveness of the widely used FIFA 11+ is not due to their CS exercises.

However a number of other factors could have had an influence on the outcome.
First, one of the biggest weaknesses of this study was the small sample size. The study included only 22 subjects. Originally there would have been 31 subjects, of which seven had to be excluded right at the beginning because they did not meet the inclusion criteria. Two more subjects had to be excluded during the testing since they were exposed to significantly different conditions (very busy environment, not possible to hear the audio signals of the test) compared to the other subjects, which leads us to the next limitation. Since the testing did not take place in a closed room, the people walking by, noise and other disturbing factors established a sub-optimal environment for testing for all subjects.
Third, due to the issue of limited time of the researchers, the subjects and the facility where the testing took place, repeated measures of the Yo-Yo IR1 could not take place. Instead, two groups with different subjects had to be compared, of which all might have a different level of fitness. This was partly taken into account by anthropometric measurements. As results in table 1 show, there was actually not a significant difference in hours of sport per week, sports intensity or leg length of the subjects in both groups, meaning the basic fitness of both groups should be comparable. The level of cardiovascular loading after the Yo-Yo IR1 in terms of heart rate was not significantly different between both groups (see table 3). Nevertheless an actual intrapersonal testing would have shown a more accurate result. For example Sato et al. (11) did find an effect in running performance when they compared post intervention to baseline measures and compared the improvements to those of the control group. However, for this specific study this might not be so suitable, since the intervention was CS warm-up and not CS training. A baseline testing without performing a warm-up program might not be executable due to ethical reasons and patient safety. The injury risk would be very high on this high intensity test.

Fourthly, due to this time issue and the availability of only one Y-balance test Kit, the subjects had a delay of some minutes after the warm-up before they were performing on the Yo-Yo IR1 test, this might have had an influence on the acute effect of the CS warm-up.
This delay was even more pronounced and might be of bigger influence for the intervention group, since they had to wait until the control group was done with the Y-balance test to be able to do the Yo-Yo IR1 together.
Fifthly, the Yo-Yo IR1 test was always done in pairs and not by single testing of the subjects since it is a test established for teams and there was a competition factor for everybody. However, the competition factor might have been stronger between one pair than the other. As shown by Cooke et al. (40) competition improved endurance performance (handgrip endurance task), increased effort, enjoyment, heart rate and muscle activity. This might have had a big influence on the outcome. Therefore, a testing of the whole group together would have made circumstances more equal for all subjects. Due to the combined study of the second researcher this was not possible.
Sixthly, the same instructions, which were established on beforehand by the two researchers, were given to the subjects via standardized sentences to exclude bias. However the instructions and corrections for the CS warm-up were given to half the subjects from one researcher and to the other half from the second researcher.
As the two above mentioned aspects, five and six, account for both groups, this can be seen as standardized errors which occurred across both study groups. Therefore the influence might be minimal.
Seventhly, there was information (Appendix IV) sent to all subject on beforehand. This was taken out of a protocol (17). Information was sent to all subjects since randomisation was done later on and possible communication between subjects could have led to knowledge of the subjects in which group they were placed and therefore bias of the result. However, some subjects from the control group understood in which group they were since they did not execute the exercises which were sent on beforehand; this might have limited their blinding.
Eighthly, two of the subjects (both allocated in the control group) did not participate with running shoes as agreed on beforehand but were running barefoot. The grip of different shoes of the subjects led to the possibility of easier turning at the Yo-Yo IR1, which cost them less energy and therefore a possible better performance.
There were mainly male subjects involved in this study, the outcome might have been different with female subjects, since there are studies like the one from Soligard et al. (39), which show effects but only include female participants.

Summarizing our and all the outcomes from the above mentioned studies, it can be said that there is not one answer to our research question; neither total rejection nor support of the hypothesis is possible. There is the possibility that CS warm-up does not have any effect on high-intensity intermittent running. Even though, there was a non-significant difference between the groups. However, it is very likely that the many limitations had an influence on the result. It should still be kept in mind that CS is important for every movement in the extremities like it is explained in the

introduction. Therefore it should not be forgotten about this treatment approach; neither in terms of injury prevention nor as for performance. If further studies were to find prove for the logical theoretical rational, this would help patients wanting to go back to their sports-activities to train more economically, energy efficient and coordinative (due to the muscle spindle activation and better coordination) (13). Treatment could be more specific, without wrong movement patterns and of a longer duration before fatigue begins (14). It might be as well of high value for sports-scientists and trainers of sports club, enabling them to make their fosterlings even more physically fit. However, all of this can just be assumed until further knowledge about the effectiveness of the approach is gained. Many other factors might have influence on the outcome of performance, making the topic relevant for further investigations.

Even though there would be a logical theoretical rational for it (10) and it is very promoted by commercial, fitness instructors as well as trainers for sport clubs there is still a lack of scientific evidence for it (6,10,37), asking for further research.

In future studies about this topic a few recommendations should be considered. First of all larger sample size would be necessary to get a more valid and reliable outcome. It would be of high value to use a more functional warm-up program for running. The research should be done on subjects of different age groups, gender and specific kinds of sports, where CS is considered important. The Yo-Yo IR1 should be performed with each subject after traditional as well as after CS warm-up to see the actual effect within the person itself. It should be done in one group so that the competition factor is the same for all. Another option would be to exclude the motivational effect by testing each subject individually. Testing outdoors, so that the slippery floor is not a disadvantage for people wearing shoes with less grip, would make all more reliable and generalizable to sports, even though the weather conditions could have an external influence. Instructions should be given by only one person on the performance of the CS warm-up to exclude possible bias, even though that might be not possible if testing of the whole group at once would take place. The testing of the performance by the Yo-Yo IR1 should be done immediately after the warm-up took place, to be able to see the acute effect.

All of this would make the outcome if CS warm-up has an effect on performance more valid and reliable.

CONCLUSION

This study did not find a statistical significant difference of CS warm-up on performance in terms of high-intensity intermittent-running compared to a control group. However, due to limitations the use of core stability in warming up should not be discouraged. Professionals should keep in mind that if activating CS by specific CS warm-up exercises leads to performance improvement, this would be not only of relevance for sports scientists and trainers but also for physiotherapists treating athletes wanting to go back to their sports-activities.

ACKNOWLEDGMENT

On this point several persons should be mentioned, which made the realisation of this experiment and report possible. First of all Jaap Jansen should be named as Supervisor for his productive feedback and guidance throughout this research project. Further thanks goes to the project co-ordinator Chris Burtin and the co-ordinator of the whole study program Paul de Meurichy, who led me through the whole four study years and made me feel at home in Eindhoven.

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Without the constant support of my parents it would have not been possible for me to enjoy this last four study years and realize to become a professional in the field I always wanted. Here my two uncles Helmut Mitterer and Valentin Troebinger should be named for their help and support in different situations. As well my brother, Philipp Mitterer deserves special thanks for always making me think bigger and giving me courage to find my way.

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APPENDICES

Appendix I: Invitation e-mail

Hallo fellow students,

Sara Miribung and I (Verena Mitterer) are currently in our last year of physiotherapy studies.

We are looking for participants for our thesis project.
This would be of great help for us and maybe useful for your own thesis in the upcoming years.

We are investigating the effect of warming up in relation to performance and prevention.

Testing will only take 1 hour and 40 minutes of your time and will be done in the SSC Eindhoven (5th – 7th April between 8:30 – 19:00). If you have a preferred time or day just let me or Sara know.

The only requirements you need to fulfill in order to participate are:
- performing at least 1h/week high intensive sports (football, tennis, basket,…)
- no injury to the lower limb and back now or in the past 2 years
- no current neurological disorders and disorders affecting balance (cold, vestibular disorder, …)
- no current disorders affecting the respiratory or coronary system

If you are willing to participate, just reply to this e-mail and you will get more information later on.

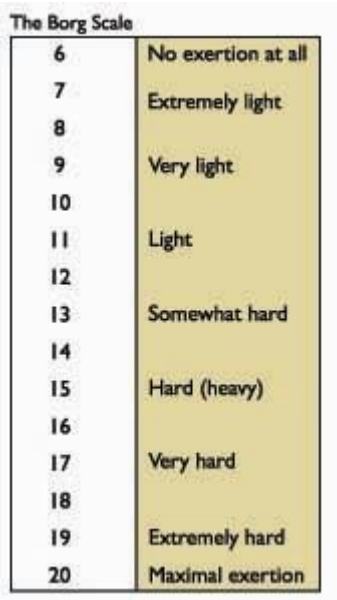
Thank you in advance for your time.
We are looking forward to every single participant.

Greetings from the mountains,
Sara and Verena

Ps: The participants can expect a small token of gratitude ;)

Appendix II: Questionnaire (anthropometric data and exclusion criteria)

- Name:
- Age:
- Gender:
- Height:
- Weight:
- Sports performance per week [h]:
- Which kind of sport:
- How intensive is this sport (surround in table. If more than one sport, indicate which one how intensive):



The Borg Scale	
6	No exertion at all
7	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard (heavy)
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

- I had an injury to the lower limb and back now or in the past two years YES NO
- I have a neurological disorders or disorder affecting balance (cold, vestibular disorder, ecc.) YES NO
- I have a disorders affecting the respiratory or coronary system YES NO
- I had a current trauma or disease elsewhere in the body within the last 2 weeks YES NO

Signature and date:

Appendix III: Informed consent

Dear Student,

We invited you to participate in our bachelor project. Before you sign for agreement we ask you to read through the following text.
Feel free to discuss the information included in this letter with family or friends, or address your questions to one of the researchers (contact details are included at the end of the text).

What is it about?
This study will investigate the effects of warming-up. Warming-up is essential for both performance and injury prevention in sports. There are many different exercises which are used for this purpose. It will be our goal to evaluate the acute effect of some of these.

Which requirements do I need to meet in order to participate?

- Performance of high intensive sports (football, tennis, basket, jogging, …) at least 1h and maximum 20h a week in average.
- No injury to the lower limb or back in the past 2 years.
- No neurological disease.
- No disorder affecting balance (cold, vestibular disorder, ecc).
- No coronary or respiratory disease.
- No trauma or disease elsewhere in the body within the two weeks prior to the testing.

When and where will it take place?
The testing will take place on the 5th till 7th of April 2013 from 8.30 till 19.00 in the Student Sport Centre Eindhoven (in front of the squash halls). The testing for each student will take 1:40h. You will get another e-mail with the exact time.

How will it work?
Within the next days you will receive e-mail with information regarding what you need to bring. The e-mail will also include two exercises. We ask you to familiarize yourself with these exercises before the testing. You do not need to train in advance; you only need to be able to perform these exercises “by heart”(you need to know them without big instructions).

Please see the following table for the build-up of the testing itself.

Duration	*Activity*	*Description*
10 min	Arrival	You will be able to change to training clothes.
10 min	Video	You will watch a video which describes the Y-balance test
10 min	Y balance test try-out	You will perform the Y balance test 6 times each leg. Measurements will not be taken yet. This test includes standing on one leg and reaching in different directions with the other leg.
20 min	Resting and leg length measurement	Your leg length will be measured by one of the researchers. This will be done in supine on a matt. You will also get some time to recover from the Y balance test try-out
5 min	Y balance test measurement I	You will perform the Y balance test one more time and measurements will be taken by one of the researchers.
10 min	Warming-up	You will get to warm-up. These might include fast walking on a treadmill (6.7km/h) and/or planking exercise and/or a side planking.
5 min	Y balance test measurement II	A second Y balance test measurement will be taken.
15-35 min	YO-YO IR1 and Y balance test measurement III	This is a test for your aerobic capacity and involved jogging as well as sprinting. Directly afterwards one last measurement on the Y balance test will be done.

Which risks might I encounter?

The risks involved in the injury are minimal. You might be fatigued after the testing, also muscle soreness cannot be excluded. There will always be two researchers present in order to observe you.

What will happen to the data?

The data will be collected on a secured lap-top. It will be analyzed and discussed in the form of a report. It will not be possible to derive your person from the results.

With this signature you give consent to the study

Date: _____-_____-_____

Name Participant: _____

Signature Participant: _____

Contact details researchers:

Verena Mitterer

Mortierlaan 2

5641 WE Eindhoven (NL)

Tel: +31 (0)6 16 03 15 75

Signature:_____

Sara Miribung

Morsestraat 1

5621 Eindhoven (NL)

Tel: +31 (0)6 44 55 52 63

Signature:_____

Appendix IV: Information letter

Hey you all!

thank you very much for filling out the forms so quickly!
Hereby I will sent you the next infos. attached you find 2 exercises you should be familiar with at the testing day and the time schedule. some the time doesn't fit for someone, let us know as soon as possible that we can change it.

As you already know testing will be done next weekend. Time schedule is attached. we will meet at the entrance of the SSC.
Since we are looking at warming up in relation to performance and prevention we ask you to look at the following description of the exercises so that you are familiar with them when you arrive at the testing day.
As well a video of the Yo-Yo IR1 test will be attached.
You do not need to train these exercises as well as the Yo-Yo IR1 test. You only need to be able to perform them correctly without big instructions on the testing day.
Please bring jogging clothes, short tight pants and running shoes with you. It is very important that you arrive in time since we are bound to a tight schedule.
See you all in the SSC Eindhoven
We are looking forward to spend some time with you thank you for your cooperation.

YOYO-Test:
http://www.youtube.com/watch?v=JwSTV3vWWzw&feature=player_embedded

happy easter already!
Verena and Sara

figure 1: Warm-up exercise retrieved from the Fifa 11+ manual. Available from http://f-marc.com/11plus/manual/.

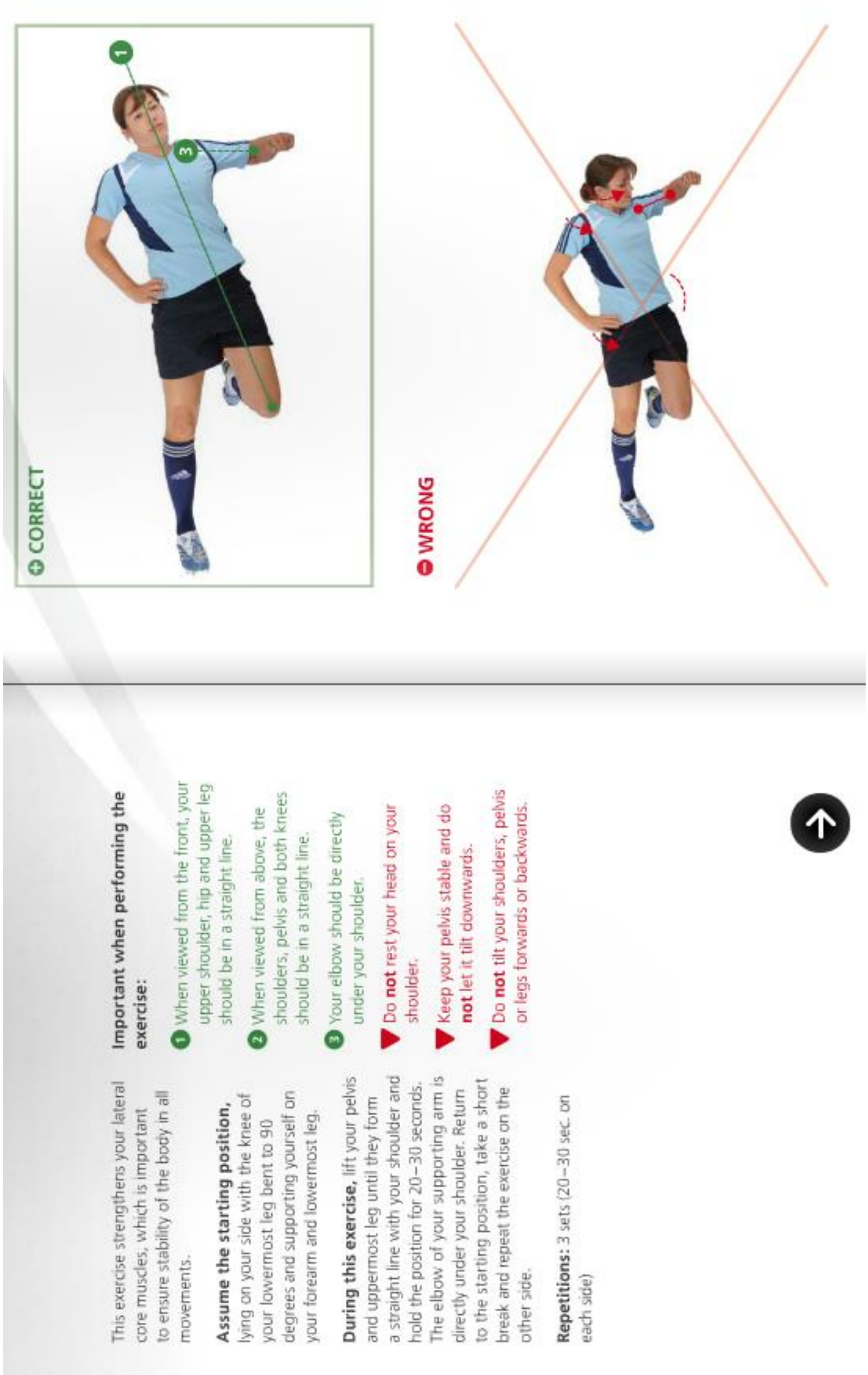


figure 2: Warm-up exercise retrieved from the Fifa 11+ manual. Available from http://f-marc.com/11plus/manual/.

Appendix V: Pictures warm-up

figure 3: Warm-up fast walking

figure 4: Intervention warm-up planking and side-bridging

Appendix VI: Pictures build up and execution of Yo-Yo IR1 test

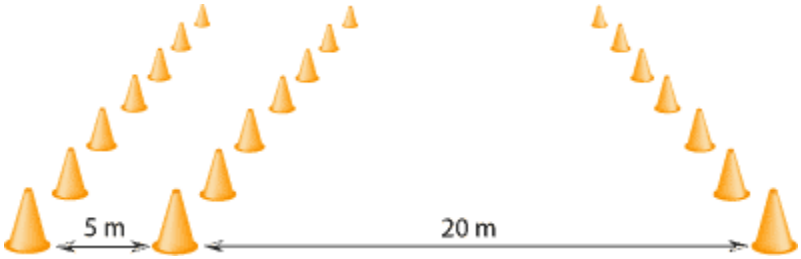


figure 5: Build-up Yo-Yo IR1

figure 6: Execution Yo-Yo IR1

Appendix VII: Histograms raw results Yo-Yo test

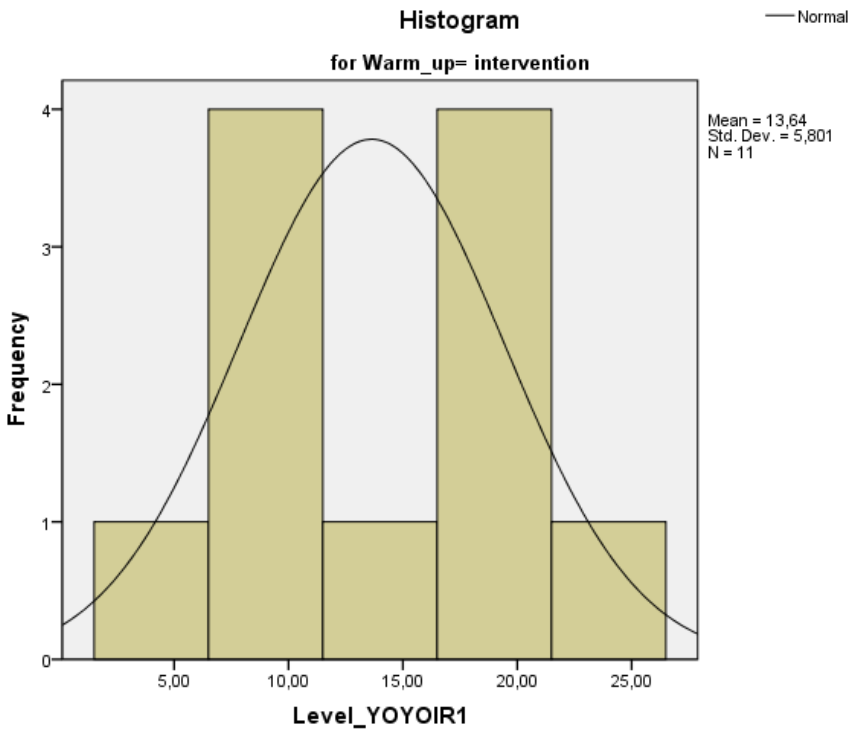


figure 7: Intervention group performance on Yo-Yo IR1

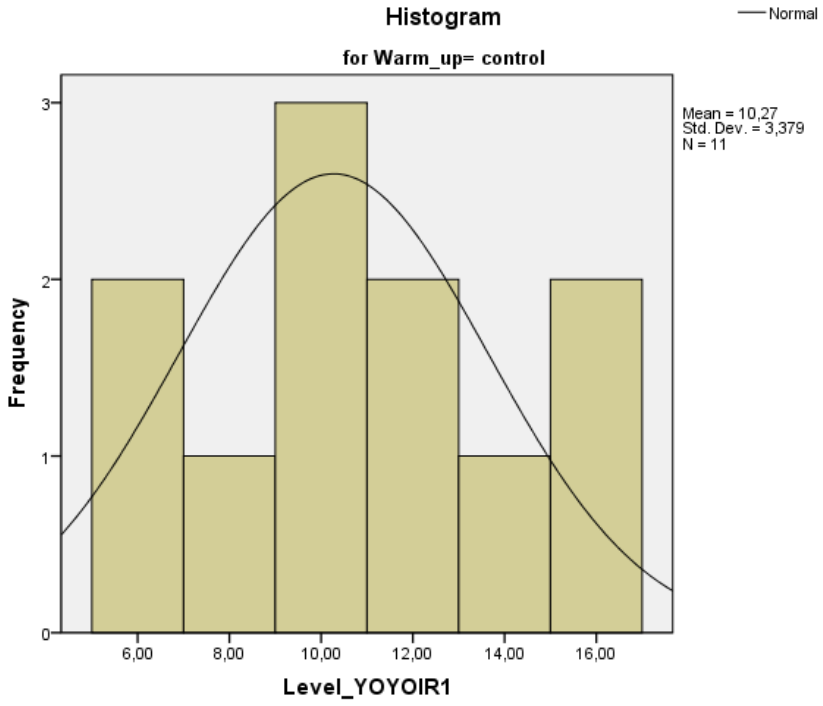


figure 8: Control group performance on Yo-Yo IR1

Appendix VIII: Approval project plan

B4 Assessment form project plan

Name: Verena Mitterer Student no:

Date: 3-2-2013

Title:is there an effect of core stability warming up on performance

General	
- The project plan is according to format	yes
- Spelling and language are correct	yes, but could be better
Problem description and problem definition (introduction)	
- The problem description is sufficiently clearly formulated	yes
- The problem description reflects social and paramedical relevance	yes
- A concrete and relevant research question (or questions) can be formulated based on the problem definition, including possible sub questions	yes
Objective	
The objective is:	
- Sufficiently clearly and concretely formulated	yes
- Relevant for a selected target group within the (paramedical) professional practice	yes
- Practically feasible	yes
- Achievable within the set time	yes
Project product: not very relevant	
The project product:	
- Is in line with the problem definition, research question and objective	yes / no
- Is usable for the selected target group	yes / no
- Is in line with the client's wishes	yes / no
- The product requirements are accurately described	yes / no
Activities/method	
Sufficient insight is given into the type of activities and types of sources for the performance of the research and the realization of the product	yes / no
Time schedule	
- The time schedule gives a global phasing and time investment for the project as a whole and for the coming weeks an increasingly detailed schedule	yes
- Important moments are recorded in the table (typographically noticeable) (e.g. contact moments, handing-in moments)	yes
- The time schedule gives a global task division of the planned activities	yes

Estimated costs

Clear insight is given in:

- The costs to be expected concerning money and hours	yes
- The division of these costs (project leader, student, programme)	yes

Literature

- Used and planned literature is specific and mentioned to a sufficient extent	yes
- Relevant and recent literature is referred to	yes
- Literature references, in the text and in the literature list, are made according to the Writer's Guide (Wouters 2012)	yes

Comments:

A bit more details on the rationale why an acute effect is expected is desired in the introduction. See comments in the product for further tips. In general, method section is well described, and gives me sufficient confidence that the project can be successful.

All points under B3.1 up to and including B3.8 must be answered with a 'yes' in order to receive a GO for the project. The supervisor discusses with the student which points need adjustment.

GENERAL: **GO**

Name assessor: Jaap Janse Date + Signature 18-2-2013

Chris Benton

Appendix IX: Confidentiality statement

Name: Verena Mitterer Student No°: 2147784

Title:

____The effect of core stability warm-up on performance_____

Content (description)**:**

Background Information. Core stability has been described to be important for limb motion, since we move in a kinetic chain rather than in single segments during complex movements. Furthermore warm-up programs have shown to enhance coordination as well as performance. The combination of the two of them, in terms of core stability warm-up, is widely used in daily practice but has to the authors knowledge not been investigated scientifically so far.

Objective. The objective of the study was to determine if core stability warm-up has an effect on high-intensity interval endurance capacity.

Design. The study was designed as a randomized prospective study.

Method. The intervention group performed planking and a side bridging exercises combined with three minutes of fast walking. The control group performed fast walking for eight minutes. Performance was measured with the Yo-Yo Intermittent Recovery Test 1 and results were compared between control and intervention group.

Results. The measurements were performed on 22 recreational student athletes, randomized into intervention (eight male, four female; median age: 24 years) and control group (nine male, three female; median age: 26 years). No significant difference was found between the two groups.

Conclusion. Based on to the results of this study, one could assume that there is no effect of core stability warm-up on performance. However due to the many limitations of the study, neither rejection nor approval of hypothesis is possible. Nevertheless the possible positive effects of warm-up as well as of core stability exercises on performance, coordination, rehabilitation and injury prevention should be further researched.

1. By signing this Statement, the Fontys Paramedic University of Applied Sciences in Eindhoven commits itself to keep any information concerning provided data and results obtained on the basis of research of which is taken cognizance as part of the above practical research project and of which it is known or can be reasonably understood that said information is to be considered secret or confidential, in the strictest confidence.

2. This confidentiality requirement also applies to the employees of the Fontys Paramedic University of Applied Sciences, as well as to others who by virtue of their function have access to or have taken cognizance of the aforesaid information in any way.

3. The above notwithstanding, the student will be able to perform the practical research project in accordance with the statutory rules and regulations.

Student:

Name: Verena Mitterer_____

Verena Mitterer_____

(signature) Date: 29/05/2013

Supervisor:

Name: Jaap Jansen_____

_____

(signature) Date:__/__/_____

Coordinator: for receipt

Name: Chris Burtin _____

_____

(signature) Date:__/__/_____

Appendix X: Conveyance of rights

AGREEMENT

Pertaining to the conveyance of rights and the obligation to

convey/return data, software and other means

The undersigned:

1. Ms Verena Mitterer_____
   [*full name as stated in passport*], residing at 39040 Vahrn (Italy) _____

   [*postal code, place of residence*] at the Schalders 52 _____

   [*street and house number*], hereinafter to be called "**Student**"

and

2. Fontys Institute trading under the name Fontys University of Applied Sciences, Rachelsmolen 1, 5612 MA Eindhoven, hereinafter to be called "**Fontys**"

CONSIDERATION

A. Student is studying at the Fontys Paramedic University of Applied Sciences in Eindhoven and is performing or will perform (various) activities as part of his/her studies, whether or not together with third parties and/or commissioned by third parties, as part of research supervised by the lectureship of Fontys Paramedic University of Applied Sciences. The aforesaid activities will hereinafter be called "**Lectureship Study Activities**". At the time of the signing of this Statement, the Lectureship of Fontys Paramedic University of Applied Sciences supervises in any case the studies listed in Appendix 1, but this list is not an exhaustive one and may change in the future.

B. It is of essential importance to Fontys Paramedic University of Applied Sciences that (the results of) the Lectureship Study Activities can be further developed and applied without any restriction by Fontys Paramedic University of Applied Sciences and/or used for the education of other students. Fontys wishes in any event – but not exclusively – (i) to be able to share with and/or convey to third parties (the results of) the Lectureship Study Activities, (ii) to publish these under its own name, where the Student may be named as co-author providing that this is reasonable under the circumstances, (iii) to be able to use these as a basis for new research projects.

C. In case intellectual ownership rights and/or related claims on the part of Student will be/are attached to (the results of) the Lectureship Study Activities, parties wish – taking into account that which was mentioned under (B) – Fontys Paramedic University of Applied Sciences to be the only claimant with regard to said rights and claims. The Student therefore wishes to convey all his/her current and future intellectual property rights as well as related claims concerning (results of) the Lectureship Study Activities to Fontys, subject to conditions to be specified hereafter;

D. Student furthermore wishes to enter into the obligation – again taking into account that which was mentioned under (B) – to convey all data collected by him/her as part of the (results of) the Lectureship Study Activities to Fontys and not to retain any copies thereof, and also to return all data, software and/or other means previously provided by Fontys as part of (the results of) the Lectureship Study Activities, such as measuring and testing equipment, to Fontys without retaining copies thereof, all the above being subject to conditions to be specified hereafter.

AGREE THE FOLLOWING

Conveyance of intellectual property rights

1.1 Student herewith conveys to the Fontys Paramedic University of Applied Sciences all his/her current and future intellectual property rights and related claims concerning (the results of) the Lectureship Study Activities, for the full term of these rights.

1.2 Intellectual property rights and/or related claims are understood to refer to, in any case – but not limited to – copyright, data bank law, patent law, trademark law, trade name law, designs and model rights, plant breeder's rights, the protection of know-how and protection against unfair competition.

1.3 The conveyance described under 1.1 shall be without restriction. As such, the aforesaid conveyance shall include all competences related to the conveyed rights and claims, and said conveyance shall apply to all countries worldwide.

1.4 Insofar as any national law requires any further cooperation on the part of Student for the conveyance mentioned under 1.1, Student will immediately and without reservation lend such cooperation at first request by Fontys Paramedic University of Applied Sciences

1.5 Fontys accepts the conveyance described under 1.1.

Waiver of personal rights

2.1 Insofar as permitted under article 25 'Copyright' and any other national laws that may apply, Student waives his/her personal rights, including – but not limited to – the right to mention Student's

name and the right to oppose any changes to (the results of) the Lectureship Study Activities. If and insofar as Student can claim personality rights pursuant to any national laws notwithstanding the above, Student will not appeal to said personality rights on unreasonable grounds.

2.2 In deviation from that which was stipulated under 2.1, the Fontys Paramedic University of Applied Sciences may decide to mention the name of Student if this is reasonable in view of the extent of his/her contribution and activities.

Compensation

Student agrees that he/she will receive no compensation for the conveyance and waiver of rights as described in this Statement.

Guarantee concerning intellectual property rights

Student declares that he/she is entitled to the aforesaid conveyance and waiver, and declares that he/she has not granted or will grant in future, license(s) for the use of (the results of) the Lectureship Study Activities in any way to any third party/parties. Student indemnifies Fontys from any claims by third parties within this context.

Obligation to convey/return data, software and other means

5.1 At such a time as Student is no longer performing any Lectureship Study Activities and/or is no longer a student at Fontys, Student is obliged to convey to Fontys all data, in the widest sense of the word, collected by him/her as part of (results of) the Lectureship Study Activities, including – but not limited to – studies and research results, interim notes, documents, images, drawings, models, prototypes, specifications, production methods, process descriptions and technique descriptions.

5.2 Student guarantees not to have kept any copies in any way or form of the data meant under 5.1.

5.3 Student is obliged to return to Fontys all data, software and other means provided to him/her by Fontys as part of the Lectureship Study Activities, and guarantees not to have kept copies in any way or in any form, of the provided software and/or other means.

5.4 Student agrees that if he acts and/or proves to have acted contrary to the obligations mentioned under 5.1 up to and including 5.3, (a) he/she shall be liable for all and any damages incurred or to be incurred by Fontys, and (b) that this will qualify as fraud and that Fontys can apply the appropriate sanctions hereto. The sanctions to be applied by Fontys may consist of, among other things, the denying of study credits, the temporary exclusion of the Undersigned from participation in

examinations, but also the definitive removal of the registration of the Undersigned as a student at Fontys.

Waiver

Student waives the right to terminate this Agreement.

Further stipulations

7.1 Insofar as this Agreement deviates from the Student Statute, this Agreement shall prevail.

7.2 This Agreement is subject to Dutch law. All disputes resulting from this statement will be brought before the competent judge in Amsterdam.

Student:	**Fontys Institute** **trading under the name Fontys Hogescholen** **Supervisor:**
Name: Verena Mitterer_____	Name: Jaap Jansen_____
Verena Mitterer_____	_____
(signature)	(signature)
Date:29/05/2013	Date:__/__/_____
Place: Eindhoven _____	Place: _____

I, Ms. M.H. de Waard, sworn translator for the English language registered at the Court in Groningen, the Netherlands, and registered in the Dutch Register of Sworn Translators and Interpreters (Rbtv) under nr. 2202, herewith certify the above to be a true and faithful translation of the attached Dutch document into the English language.

Groningen, 23 May 2012,

[M.H. de Waard]