Bachelorgradsoppgave

Supramaximal and Resistance Sprint, The Acute Effect

Comparison of supramaximal and Resistance sprint, And The Acute Effect on sprint Performance

Forfatter Kim André Kvamvold

KIF 350

Bachelorgradsoppgave i Kroppsøving of idretts-faglærerutdanningen

Avdelingen for lærerutdanning
Høgskolen i Nord-Trøndelag - 2015

HINT

SAMTYKKE TIL HØGSKOLENS BRUK AV KANDIDAT-, BACHELOR- OG MASTEROPPGAVER

Forfatter(e): Kim André Kvamvold

Norsk tittel:

Engelsk tittel: Comparison of Supramaximal and Resistance Sprint, And The Acute Effect On Sprint Performance

Studieprogram: Kroppsøving og idrettsfag – faglærerutdanning

Emnekode og navn: KIF 350

[X] Vi/jeg samtykker i at oppgaven kan publiseres på internett i fulltekst i Brage, HiNTs åpne arkiv

[ ] Vår/min oppgave inneholder taushetsbelagte opplysninger og må derfor ikke gjøres tilgjengelig for andre

Dato: 29.05.15

Kim André Kvamvold
Underskrift

____
Underskrift

Comparison of supramaximal and Resistance sprint, And The Acute Effect on sprint Performance

Abstract

Aim of this study was to compare supramaximal and resistance sprints, and see if this type of sprinting had an acute effect on sprint performance (sprinting time and velocity).

Method

14 well trained students and athletes participated in this study. Subjects tested three different sprint protcols (supramaximal, resistance and normal) over three weeks, one at each week. Each test protocol consisted of a general warm-up and a sprint protocol. A sprint protocol consisted of 7 sprints alternated between normal sprints and supramaximal or resisted sprints. To see an acute effect of either PAP or transfer the subjects got 4 minutes break between each sprint.

Results

No significant changes was found in performance variables (sprinting time and velocity) at the normal sprints after doing supramaximal or resistance sprints. The most important findings we did were the performance related variable contact-time after they have done a resisted sprint. Significant changes from sprint one (normal sprint) and three (normal sprint) (P=0,01) was found in the resistance protocol. Sprint three (normal sprint) and five (normal sprint) in the normal protocol had also a significant change in contact-time, the contact-time was longer in sprint five. A significant longer contact time was found in the supramximal protocol between sprint one (normal) and sprint three (normal)

Conclusion: The most important findings we did were the performance related variable contact-time after they have done a resisted sprint. After doing resisted sprint the subjects got a significant longer contact-time in all of the normal sprints. A larger fatigue was also found in this the resistance protocol compared to the other protocols. This indicates that doing resistance sprinting make more fatigue in the acute state and makes the contact-time longer when sprinting in normal sprint condition. In the last sprints at the normal sprint protocol we found a significant change in contact-time, this probably indicate fatigue. In the normal sprint protocol the contact-time was longer in sprint five than sprint three, this can indicate fatigue.

Contact-time between sprint one and three in supramaximal protocol was found longer in sprint three. We cant provide any answer to these findings. In general sports applications the resistance sprinting do not make the contact-time in sprinting shorter, it seems like the contact-time is being longer after doing resisted sprints. We can`t say for sure because this was a study on the acute effect not the long term effect.

Key Words: Resistance Sprint, Supramaximal Sprint, Acute Effect, PAP, Transfer, Force-Velocity

Innhold

ANTALL ORD: 5075

1. Introduction

Doing resisted and supramaximal sprint have been done by many athletes over decades. It is well accepted among trainers and athletes that sprinting with resistance will make you faster, on the other side the scientist are not a fan of resistance sprints. Scientist has found a transfer between supramaximal sprinting and sprint performance, this is training studies and the scientists can`t answer if the supramaximal or resistance sprints have an acute effect on sprint performance. This is because of the unclear literature at this point. Resistance sprints are done specially by track and field athletes and in some cases in soccer. Several training studies have shown both positive and negative effect of using resistance sprints and supramaximal sprints (Van Den Tillar R. 2004; Kristensen et.al 2006; Tillin & Bishop 2009). For general application to sport we wanted to see at the acute effect of using supramaximal and resisted sprint before testing sprint performance.

It is well-known that the specific transfer theory is related to training at high velocities and get transfer to lower velocities (Kristensen et al. 2006;Toji & Kaneko, 2004; Tillar, 2004; Kaneko et al. 1983; Behm & Sale, 1993; Cronin et al. 2001; Young, 2006). PAP theory is related to warm-up and performance changes in explosive movements after doing movement with heavy resistance (Tillin & Bishop, 2009; Wilson et al.2013).

Specificity and transfer

Specificity is well explained in Young (2006). He says that movement that has similarity in contraction, force and movement patterns are specific to each other. Specificity is all about how similar the training is to the competition (Young, 2006).

Transfer is a subcategory of specificity. How well do you transfer from training to competition? Young (2006) pointed in his study gains in exercise = gains in performance = good/positive transfer . Transfer can be detected in Positive and Negative transfer. Negative transfer occurs when the athlete has increased activation of antagonists. This activation results in forces that are going in opposite direction than the intended movement direction. This will cause bad «intramuscular coordination» and effect performance. A study on knee flexion training and

knee extension testing are example on higher antagonist activation after training in a certain way. The subjects got higher activation of knee flexors under testing of the knee extensors; this was after they had trained the knee flexors (Baretta et al.1988).
Positive transfer can be related to increased performance. Young (2006) is using an excellent example from sprint performance. Sprinting is all about making force from one leg muscles horizontally (unilateral). Using bilateral exercises that provide force in the vertical plane, such as squats and jump squats, have minimal transfer to sprint performance (Young 2006). Wilson (1996) came to same conclusion. The subjects trained Heavy resistance squat, they increased 21% in one-repetition-maximum (1RM) squat, increased 21% in vertical jump and increased 2.3% in 20 meter sprint performance. Young (2006) claims that there is good transfer from doing squats and increased performance in 1RM squat and vertical jump, there not so much transfer from squat (bilateral exercises) to sprint performance (unilateral exercises). However, young claims that including plyometric, unilateral exercises in the horizontal plane, elicits significant increase in sprint acceleration performance (Young et al. 2006; Wilson et al. 1996).

PAP

Post Activation Potentiation is a phenomenon that can occur after doing heavy resistance movements. The theoretical aspect of PAP is related to the muscles contractile history. When you do a near maximal contraction of the muscle (80-100% of 1RM), the 4-7 minutes after you will have a PAP effect that gives you higher rate of force development and increased peak force output. Doing heavy squats before doing plyometric jumps, or doing resistance sprint before a regular sprint are practical examples (Tillin & Bishop 2009). Inducing PAP prior to competition might prove better results than conventional warm-up routines at enhancing explosive performance (Gullich & Schmidtbleicher 1996; Tillin & Bishop 2009). Many trainers and athletes have done warm-up and induced PAP as a warm-up. Sprinters and track/field athletes have used heavy squats and resistance sprint before competition to get increased performance. Some studies shows the PAP effect on heavy resistance warm-up resulting in higher power output (Gullich & Schmidtbleicher 1996; Tillin & Bishop 2009), but the literature are inconsistence and the possible effect of PAP is still unclear. Some studies shows negative effect (-1-3%) on sprint performance (30 m) after doing heavy back-squats 3-5 min before sprinting (Chatzopoulos et al.2007; Tillin & Bishop 2009). Other studies shows positive PAP effect on counter movement jump after doing heavy squats (1-3% increased performance) (Chiu et al. 2003; Tillin & Bishop 2009).

Transfer/specificity of force and velocity

Maybe this theoretical aspect can explain why PAP does or does not work. We can link it to the theory of transfer and force-velocity. If you are doing heavy resistance squat (80%-100% 1RM) will you get increased performance in sprint, jumps squats or heavy resistance squat (80% 1RM)? In this theory you will most likely get a bit increased performance in jump squat, most in heavy resistance squat and not so much in sprint. This is because the contraction velocity and movement pattern is more similar in squat and jump squat than sprint (Young 2006). Several studies are showing that when you train a movement at a specific velocity you get best results when testing at the velocity you trained at. Lemes found that when you train strength at a specific velocity (slow, mid or fast) you only get increased performance at the trained velocity when testing at three different velocities (slow, mid and fast) (Lemes et al.1978). Other studies show a transfer from training at high velocity and testing at slower velocities. When you flip it, there is a negative transfer (training at slow, testing at fast). If you train at a slow velocity, you do not get transfer when testing at higher velocities than you trained at (Lemes et al. 1978; Caoizzo et al. 1980; Knapic & Ramos 1980; Mofforoid & Whipple 1970; Kaneko et.al 1983).

Hill curve

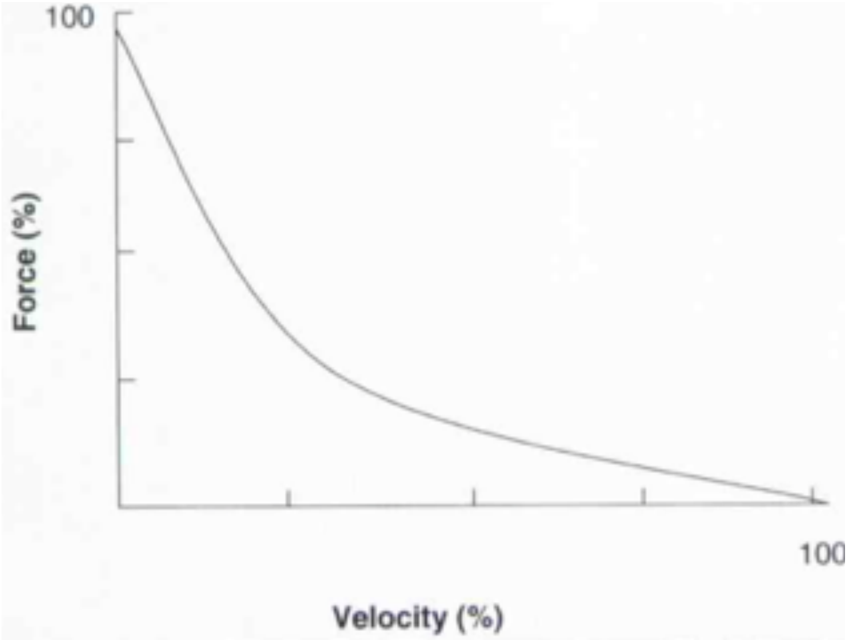

Fig.1. *Classic force-velocity curve of a muscle contraction (Hill curve) (Van Den Tillar. R. 2004)*

Hill curve explains the relationship between force and velocity. When you sprint at maximal velocity you cant produce a great amount of force. If you don't sprint with maximal velocity the force you can produce are grater. Slower movement can make greater force than fast movements (Van Den Tillar, R. 2004)

Aim of the study

The aim of this study was to compere supramaximal and resistance sprints and see if there was an acute effect on sprint performance (20 m). This is a question that is difficult to answer because the studies done at this point is unclear. Many studies have been done on the PAP effect and the force-velocity transfer, but this is training studies and the acute effect is still unclear.

METHODS

Exprimental Approach to the problem

In this study we compared different sprint protocols and if this could affect 20 meter sprint performance. We studied one group (n=14) who executed three different sprint protocols in counter balanced order: general warm-up + normal sprint protocol, general warm-up + resistance sprint protocol and general warm-up + supramaximal sprint protocol. The aim of this study was to determine the acute affect of supramaximal and resistance sprint on 20 meter sprint performance.

Subjects

14 well-trained students and athletes participated in this study (14 boys, age, 19,0 ± 4,1 years; weight, 70,1 ± 10,7 kg). Athletes and well-trained students were included in the study because of a possible effect of PAP and to provide and answer for general application in sports (Wilson, J.M. et al. 2013). The participating subjects did not have any background from systematic sprint training. The subjects were informed about the consequences and they signed a paper, and they got verbal instructions about the tests. The pretest meal had to be minimum to hours before testing, no alcohol before testing and they could choose to leave the study at any time. They tested three times in three weeks and the testing was done at the same day in every week. Two of the subjects was excluded from the study because they missed 2 of the testing sessions.

Test protocol

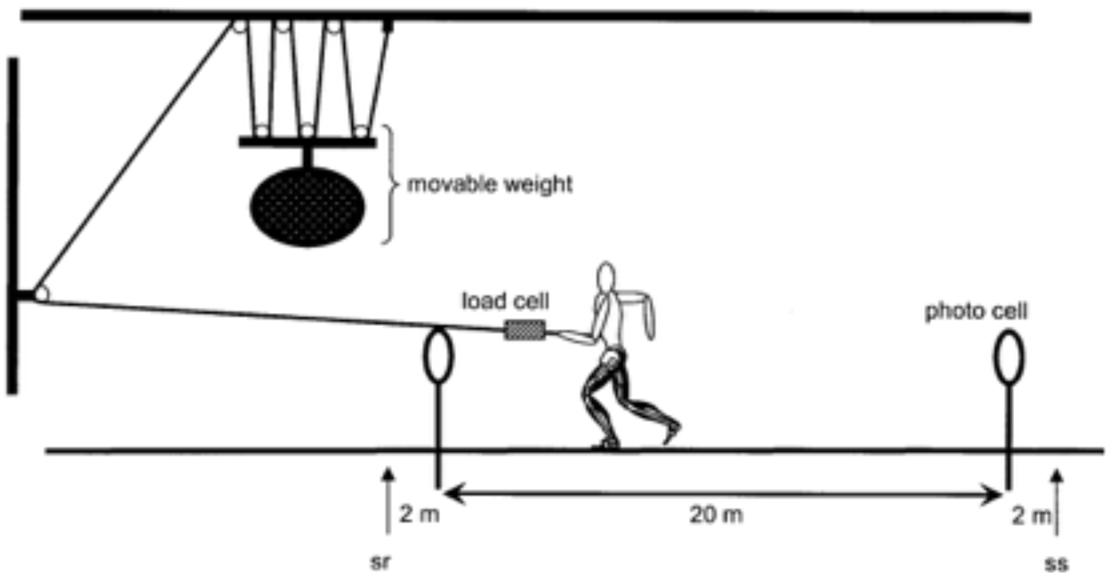

Fig.2. *Showing the set-up of towing system and the subject running in supramaximal (ss) and resisted condition (sr). Running performance was measured between the 2 photocells (20 m). The load cell was only used to calibration and calculate the appropriate weight attached. Towing device was attached to the hip and not the upper body (Kristensen et al. 2006).*

Warm-up

The subjects executed one sprint protocol at each test-day and three different sprint protocols over the three weeks of testing . All three protocols consisted of one general warm-up (10 min slow/moderate running) followed by dynamic stretching and one or two sub-maximal sprints if they wanted to. All sprint protocols consisted of four «performance tests» (4 normal sprints) and alternated with a «impact tests» supramaximal or resisted sprint between. This was to determine the acute effect from the supramaximal and resisted sprints. The first sprint is just a short pretest that shows us a sprint without any impact from supramaximal or resisted sprinting, later we can compare the first sprint and sprint three, five and seven. We call the normal sprint «performance test» and supramaximal/resisted sprints «impact» sprints. Between every sprint the subjects got 4 minute break. This was to ensure that the subjects had minimal fatigue and there is a possible effect of PAP we wanted to investigate (Wilson et al. 2013).

Sprint protocols

Normal sprint protocol	Supramaximal sprint protocol	Resistance sprint protocol
Normal sprint	Normal sprint	Normal sprint
Normal sprint	Supramaximal sprint (impact)	Resistance sprint (impact
Normal sprint	Normal sprint (performance test)	Normal sprint (performance test)
Normal sprint	Supramaximal sprint (impact)	Resistance sprint (impact)
Normal sprint	Normal sprint (performance test)	Normal sprint (performance test)
Normal sprint	Supramaximal sprint (impact)	Resistance sprint (impact)
Normal sprint	Normal sprint (Performance test)	Normal sprint (performance test)

Fig 3. *Schema of the different sprint protocols and how they alternate between normal sprint and supramaximal/resisted sprint. The sprints in outlined in red are «impact» sprints, and the alternated normal sprints are «performance test».*

Control of steel

Supramaximal and resistance sprinting was done using a towing device (figure 1). This device provided extra propulsion force or extra resistance depending on the running direction. In this device it was used seven castors (three fixed to the ceiling, one at the wall at a hight of 1.5 m, and three on a movable fixation bar) which created a 1:6 gearing system between weight and subject. A 5-mm rope was fastened in the roof 7 m above the floor. The rope was fastened at the hip of the subject with a belt and led through the castors. The appropriate weight was attached to the moveable bar, this caused at relative small change in running velocity so the running technique were comparable with each other (Kristensen et al. 2006). The running velocity was (+) 7% at supramaximal sprinting and (-) 5% at resisted sprinting. 5 kg were used in resisted sprints and 40 kg were used in supramaximal sprints

All subjects were instructed to run with maximal effort in all trials. All subjects did seven sprints and alternated between normal and specific sprints (except from normal protocol). The normal sprints in all protocols was a «performance test» (sprint three,five and seven) to see the acute effect from the «impact sprints» (sprint two, four and six) (fig1).

Photocells and lasergun was used to measure the performance variables (time and velocity) at 20 m sprint. The photocells were placed at start line (0 m) and finish line (20 m). Laser was placed at the same place every time (3 m behind the subject), and the laser was pointing right at the subject during the sprints. Performance related variables (acceleration, steplength, contact-time and stepfrequency) was measured using Musclelab laser gun, Muclelab IR Contact-mat, Musclelab IMU (Ergotest innovation AS,Norway). All sprint times were recorded and average sprinting time was calculated in Microsoft Exel. The velocity was measured with a laser gun, but was also calculated later in Microsoft Exel (distance divided at sprinting time). The subjects started every sprint with the toe at the start line. They were asked if they were ready to run, if they answered yes we counted down from three and they run. The laser had to point right at the hip of the subjects and the subject had to run straight forward. A straight forward track of tape was made at the running surface (tartan surface) so the subject could run straight forward.

Statistical Analyses

In this study horizontal and vertical t-test was used to compare the specific sprints with the normal sprints. To compare the different sprint protocols with each other the vertical t-test was used, and to compare the different sprint in the same protocol a horizontal t-test was used. For all tests the probability level for significance was set at $p \leq 0.05$. All results are represented as average values and standard deviation. Some values are represented in percentage, this was done using Microsoft Exel.

Results

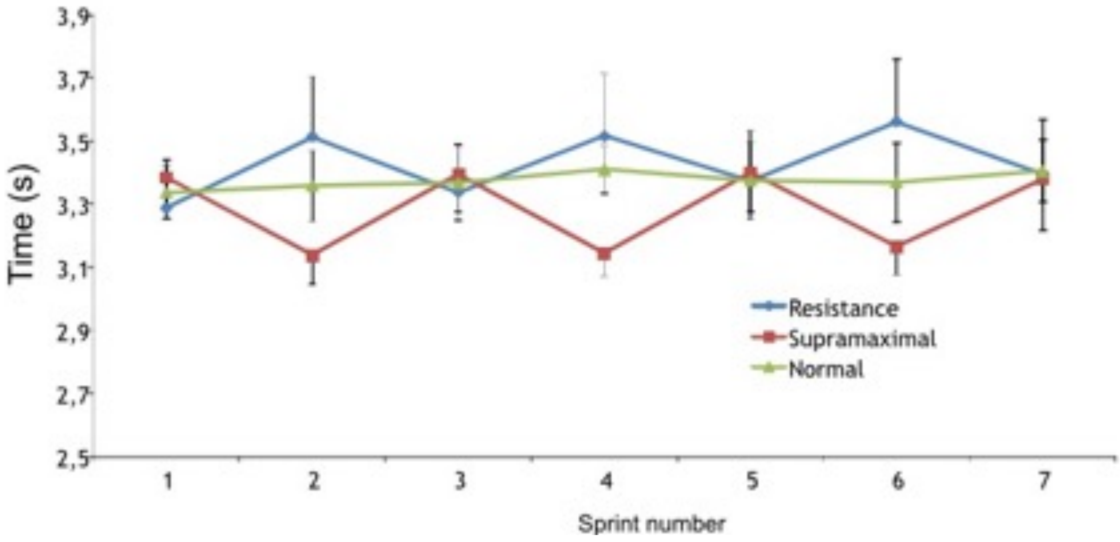

Fig.4. *Comparison of resistance, supramaximal and normal sprinting-times (s). The graph shows average sprinting times of the participating subjects. Sprint one is normal sprint in all protocols, and its alternated with specific and normal sprints in all 7 sprints.*

Graph shows how the subjects sprinting-times behaves from the first sprint to the last. The sprinting times behaves different in resistance, supramaximal and normal protocol. Resistance-graph shows when subjects sprint with resistance they got a significant slower sprinting time (+5%) (average P=0,02) compared to the normal sprint protocol. In the supramaximal protocol the subjects sprinting-times behaves opposite from the resistance protocol. When they sprint supramaximal they got a faster sprinting time then normal protocol (-7%) (average P=0,01), this was a significant change in sprinting time. Normal graph show the sprinting times in seven normal sprints. The sprinting time changes in this graph is 0,5%-1,2% and this was not a significant change. There was no significant change in sprinting times between the alternated normal sprints in non of the protocols.

There was not found any significant changes in sprint time (s) between sprint one, three, five and seven in the supramaximal protocol. No significant difference was fond in the resistance protocol either, but we see a negative tendency. After the first resistance sprint the sprint time in the normal sprints are slower a bit slower (P=0.09), but this is not significant.

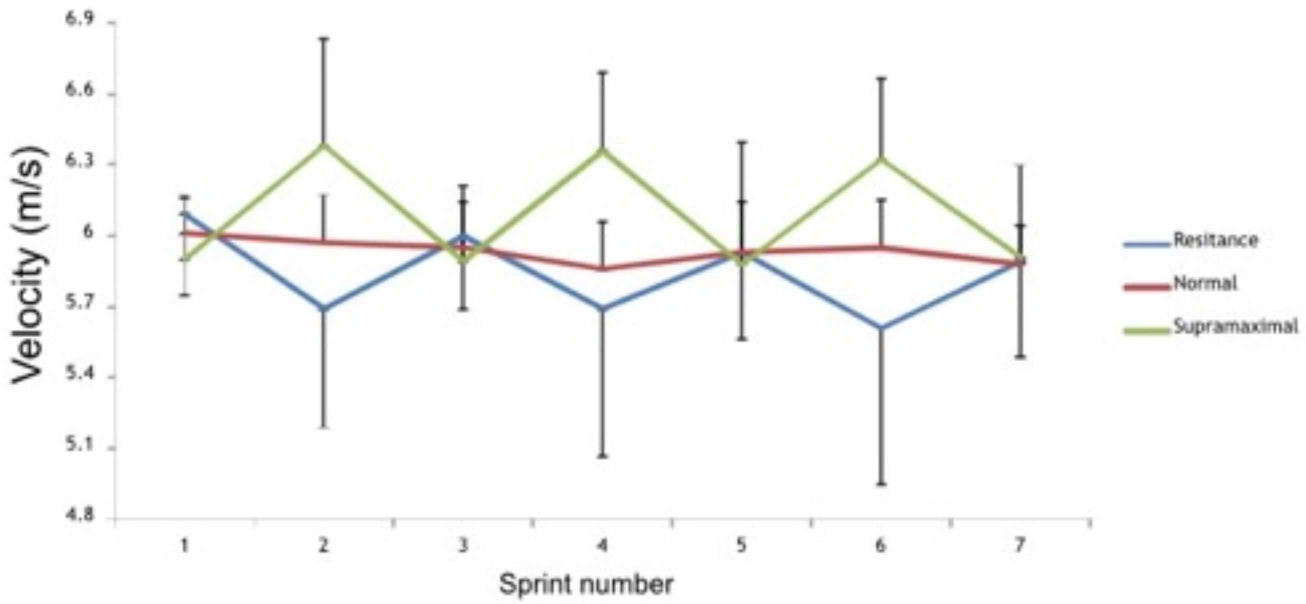

Fig.5. *Comparison of velocity in the different sprints protocols. The graph shows average sprinting velocities.*

The figure shows velocity-changes among the different sprinting protocols. The biggest velocity-change is the supramaximal protocol. Supramaximal protocol had a change in velocity at (+)7% between the normal and supramaximal sprints. Resistance protocol had a change in velocity at (-)5% between the normal sprints and resistance sprints.

No significant changes was found between the «performance tests» (sprint three, four and seven) at any of the protocols. We can see a tendency that the velocity are getting slower already from the first «impact sprint» in the resistance and supramaximal protocol. In the resistance protocol the velocity is getting lower after each «impact» sprint, and it seems like the fatigue is larger in the resistance protocol than supramaximal protocol. The difference from the first sprint to the last sprint in resistance protocol i 4 %. The supramaximal protocol did not have the same fatigue, they had actually 1-2 % faster sprint in the last sprint compared to the first sprint in the supramaximal protocol, this is not significant changes, and the normal protocol had the same results, they run 1-2 %faster in the last sprint compared to the first.

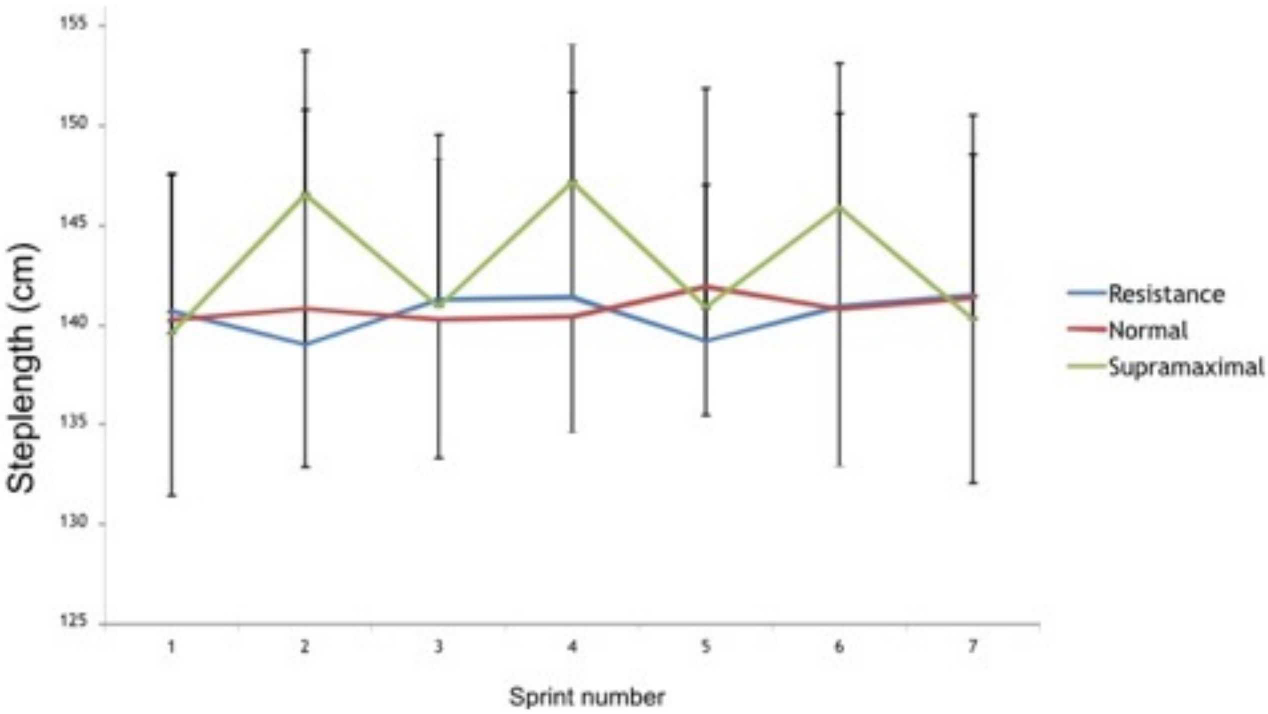

Fig.6. *Step-length comparison between the different sprint protocols. The graph shows average step-length (cm) in every sprint in each of the protocols.*

The graph shows the step-length variation in each sprint and comparison of the protocols. The only significant difference was found in the supramaximal sprint protocol compared with resistance and normal protocol (average P=0,03). There was found a significant change between sprint three and five in the resistance protocol (P=0,02).

Between sprint three and five (performance tests) in resistance protocol there was found a significant change in steplength (P=0,02). The steplength was shorter in sprint five than sprint three and one (normal sprints).

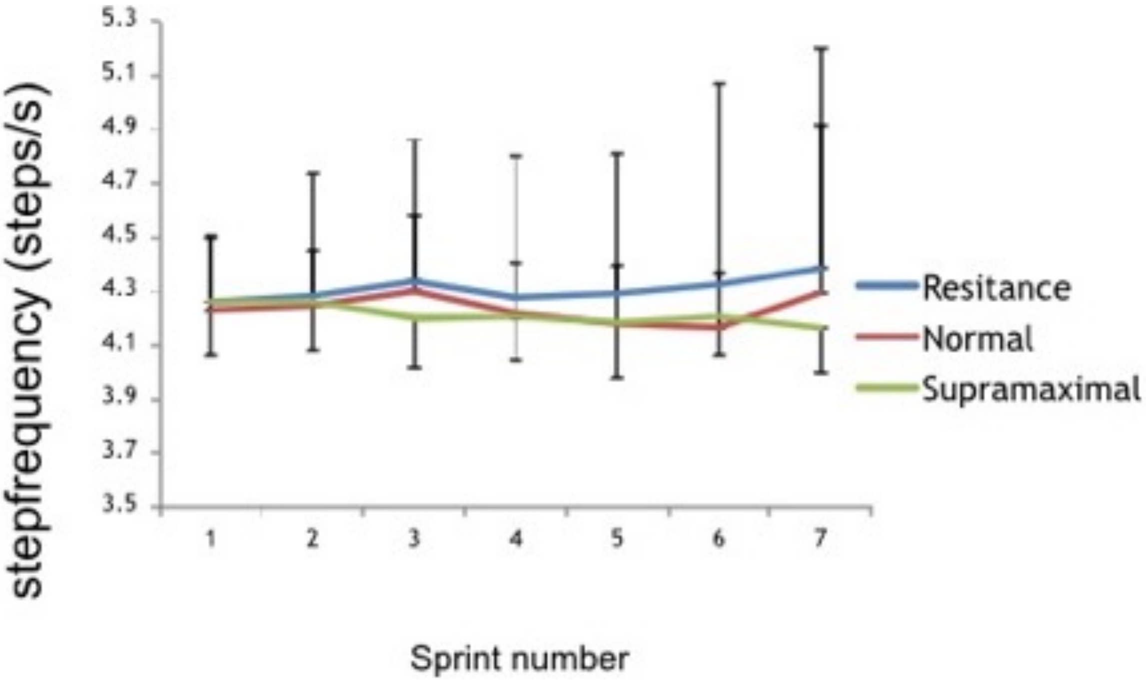

Fig. 7. *Comparison of step frequency among the different sprint protocols.*

No significant differences were found in step frequency among the different sprint protocols. There was found a significant higher step frequency in sprint three and five in the normal protocol (P=0,02). There was found a significant lower step frequency in sprint three and five in resistance protocol (P=0,02). This could indicate some fatigue.

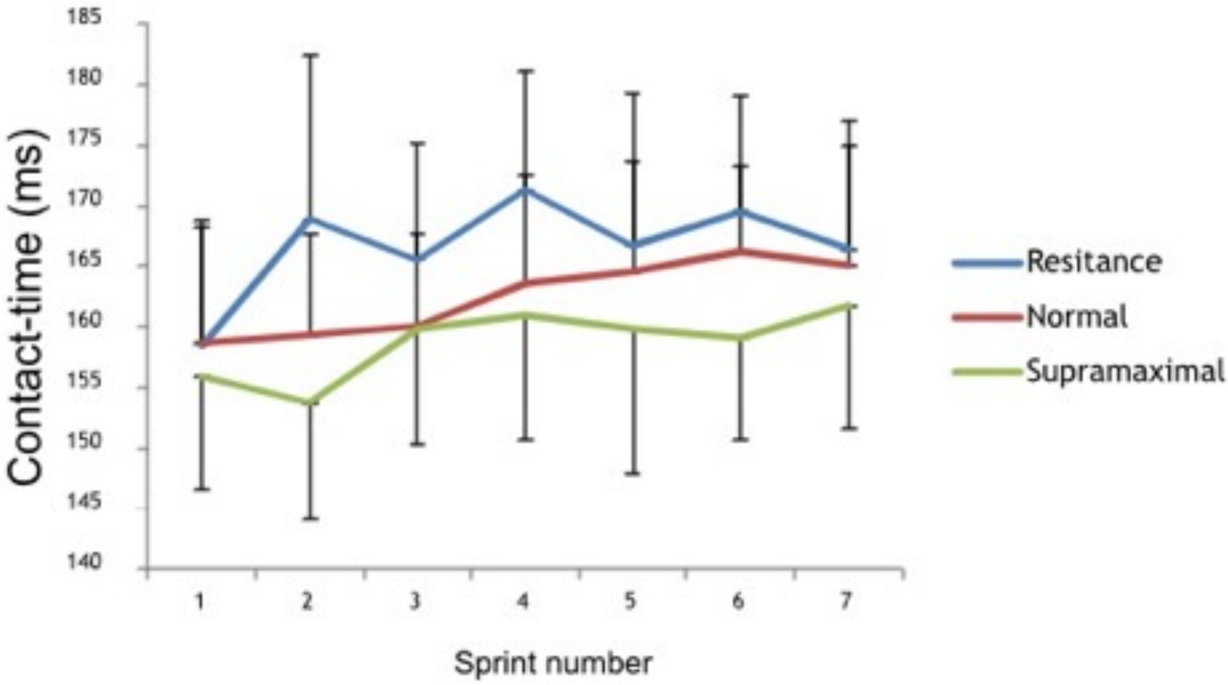

Fig. 8. *Comparison of average ground contact-time between the different sprint protocols. Contact-time was measured at each step in all sprints in the protocol. This is the average contact-time the subjects had at each sprint.*

The graph shows the difference in ground contact-time between the protocols. There was found a significant higher contact-time in resistance sprint than normal sprint (average P=0,02) . All sprints in supramaximal protocol was significant lower contact-time than normal protocol (average P=0,01). There was found a significant change in contact time between sprint three and five normal sprint protocol (P=0,04). Significant changes from sprint one and three was found in the resistance protocol (P=0,01). A significant longer contact-time was found in the supramaximal protocol between sprint one and three.

Discussion

In this study we hoped to see a change in velocity and time in the alternated normal sprints at the resistance and supramaximal protocols. We did not find any significant changes in sprinting time or velocity that could indicate an increased performance change in normal sprint after using supramaximal or resistance sprints. The only change was slower sprinting time and velocity in the last sprints, this was not significant and most likely fatigue.

The most important findings we found were the change in contact-time between sprint one and three in the resistance protocol (fig.8, blue line). If we look at the average contact-time in normal sprint vs. resistance sprint protocol, the contact-time in resistance is significant longer than normal sprint. This is because of the extra weight the subjects have to move, the velocity are slowed down and the force production is greater in the resisted sprints. This is the same principle we find in the Hill curve (fig.1).

The specific/transfer theory pointing at the transfer from doing movement with higher velocities than you normally do, will in some cases increase performance at the same movement done with slower velocity. Movement done with slower velocities than you normally do can in some cases make you slower (Kristensen, Tillar & Ettema, 2006;Toji & Kaneko, 2004; Tillar, 2004; Kaneko, Fuchimoto, Toji & Suei, 1983; Behm & Sale, 1993; Cronin, McNair & Marshall, 2001; Young, 2006).

Contact-time resistance protocol

Contact-time in the first sprint are short (resistance protocol), the second sprint (resistance sprint) are longer (+6%). In sprint three (normal sprint) the contact time is longer (+4%) than the first sprint (normal sprint). This is most likely not caused by fatigue because it is too early in the session. The transfer/specific theory can explain the findings in this study. Kristensen et al. (2006) found similar findings on the sprint time and velocity. They found a negative transfer from training resistance sprints and normal sprint performance (20 m). When they trained with resistance the sprint performance decreased in normal sprint condition.

Contact-time supramaximal protocol

After doing a supramaximal sprint the subjects got 2-3% longer contact-time when they did the next normal sprint. These findings are difficult to explain because it is probably not fatigue, it is too early in the session for fatigue. The resistance protocol had a significant longer contact-time (P=0,05) than normal sprint. Supramaximal protocol did have the same significant changes in contact-time, the only significant contact-time is between the first and the second sprint. And because of this it is difficult to see a specific pattern. Since the supramximal protocol did not have several runs with the same significant difference. The average contact-time in supramaximal sprints are not significant compared to the normal sprints in the protocol.

Fatigue

We did find significant changes in contact-time between sprint three and five in normal sprint protocol. The contact-time was longer in sprint five than sprint three (fig.8). These findings can be caused of fatigue after doing several sprints. Fatigue was found in all parameters we measured (time, velocity, step-length, step-frquency, contact-time), but was not significant changes. Performance decrease and fatigue starts at sprint four or five in supramaximal and resistance protocols. The normal sprint protocol is a little bit different; some had their best sprint at the last sprint and some at their first sprint.

Findings on PAP

In this study we hoped to find some PAP effect from the resistance sprints. No PAP effect was found, the reason for this can be the linked to the fact that there was no significant changes in sprinting time og velocity between resistance and normal sprints. The weight attached to the towing device was 5 kg for all subjects. Some studies shows the PAP effect occur at 80-100% of 1 RM intensity (Tillin & Bishop ,2009). The weight attached to the subjects should have been increased if we wanted a significant difference in sprint time and velocity. It is difficult to answer if this would cause a PAP effect and increase the sprint performance, the literature are unclear at this point. Kristensen et at.(2006) found not at PAP effect, and the weight attached to the subject was 15 kg in the study, the sprinting time was 8% difference between resistance and normal sprint. Maybe we have to increase the weight so the sprinting time have a difference at 20% or more compared to normal sprint? Reason for the low weight in this study was to be sure that the running technique was the same in all sprint protocols. If too much weight are attached, the running technique most likely will be changed.

Conclusion

This study shows no significant difference in the performance variables (sprinting time and velocity) between the normal sprints (performance tests) in the sprinting protocols. We cant find any acute effect of doing supramaximal or resistance sprints on sprint performance. Because of to less force at the resistance sprints the velocity and sprinting time were not so significant as we wanted to be, and therefor it was impossible to see a possible PAP effect from the resistance sprints. The supramaximal sprint was significant enough, but we didn't find any change in the performance variables (sprinting time and velocity).

Contact-time was the only significant changes we found. Subjects had a significant change in contact-time after doing a sprint with resistance. They had a longer contact-time in all of the sprint they did after the resistance sprints and they got faster fatigue from the resistance sprint than supramaximal sprints. Longer contact-time after resisted sprint indicates sprinting is specific, because a resisted sprint have longer (+5%) contact-time than a normal sprint. We cant claim it for sure, but it can be the resisted sprint have a negative acute effect, contact-time is not a performance variable, but it can explain performance some times. If athletes wants to specific shorten their contact-time in an acute state they maybe not want to use resistance sprints.

References

- Baratta R., Solomonow M., Zhou B.H.,Letson, D., Chuinard, R.,D´Ambrosia, R. (1988) Muscular Coactivation: The role of the antagonist musculature in maintaining knee stability. *American journal sports medicin, 16(2), 113-122.*

- Behm, D.G. & Sale, D.G. (1993) Velocity Specificity of Resistance Training. *Sports medicine, 15(6), 374-388.*

- Caiozzo, J., Perrine, T., Edgerton, V.R. (1981) Training induced alterations in the in-vivo force-velocity relationship of human muscle. *Journal of Applied Physiology, 15, 750-754.*

- Chatzopoulos, D.E., Michailidis, C.J., Giannakos, A.K. et al. (2007) Post activation potentation effeects after heavy resistance exercise on running speed. *Journal of strength Conditioning Research, 21(4), 1278-1281.*

- Chiu, L.Z., Fry, A.C., Weiss, L.W., et al. (2003) Post activation potentation response in athletic and recreationally trained individuals. *Journal of strength Conditioning Research, 17(4), 671-677.*

- Cronin, J., McNair, P.J. & Marshall, R.N. (2001) Velocity Specificity, Combination Training and Sprt Specific Tasks. *Journal of Science and Medicine in Sport 4(2), 168-178.*

- Gullich A, Schmidtbleicher D.(1996) MVC-induced short term potentation of explosive force. *New studies in Athletics,11(4), 67-81.*

- Hill, A.V. (1963) The efficiency of Mechanical Power Developement During Muscular Shortening And Its Relation To Load. *Department of physiology, University Collage London, (19), 826.*

- Toji, H. & Kaneko, M. (2004) Effect of Miltiple-Load Training on the Force-Velocity Relationship. *Journal of Strength and Conditioning Research, 18(4), 792-795.*

- Kaneko, M. Fuchimoto, T. Toji, H. & Suei, K. (1983) Training effect of different loads on the force-velocity relationship and mechanical power output in human muscle. *Scandinavian Journal of Medicine & Sciens in Sports, 5(2.), 50-55.*

- Knapik, J. & Ramos, M. (1980) Isometric and isokinetic torque relationships in the human body. *Archives of Physical Medicine and Rehabilitation, 61, 64-67.*

- Kristensen, G.O.,Van Den Tillar, R. & Ettema, G.J.C. (2006) Velocity Specificity In Early-Phase Sprint Training. *Journal of Strength and Conditioning Reserach, 20(4), 833-837.*

- Lemes, G. (1978) Muscle strength and power changes during maximal isokinetic training. *Medicine and Science in Sports and Exercise, 10, 266-269.*

- Mofferoid M. & Whipple, R.H. (1970) Specificity of speed of exercise. *Physical Therapy, 50, 1692-1700.*

- Tillin, N.A. & Bishop, D. (2009) Factors Modulating Post-Activation Potentation and its Effect on Performance of Subsequent Explosive Activities. *Sports Med, 39(2), 147-166.*

- Van Den Tillar, R. (2004) Effect Of Different Training Programs On The velocity Of Overarm throwing: A Brief Review. *Journal of Strength and Conditioning Research, 18(2), 388-396.*

- Wilson, M. J., Duncan, N.M., Marin, P.J., Brown, L.E., Loenneke, J.P., Wilson, S.M.C., Jo, E.,Lowery, R.P. & Ugrinowitsch, C. (2013) Meta-Analysis of Postactivation Potentation and Power: Effects of Conditioning Activity, Volum, Gender, Rest Periods, and Training Status. *Journal of Strength and Conditioning Research, 27(3), 854-859.*

- Young, W.B. (2006) Transfer of Strength and Power Training to Sports Performance. *International Journal of Sports Physiology and Performance, 1, 74-83.*