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Research Article

Effect of Lower Back Extensors Fatigue on Athletic Performance Measured as Agility

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ABSTRACT

Background: At high level of competition, sports require long periods of hard physical work. Each athlete should be able to perform desired actions efficiently, which will not be possible without coordinated activation of muscles in the kinetic chain. EMG studies demonstrate that lumbar paraspinal muscles fatigue is associated with Quadriceps Inhibition (QI), leading to speculation that these changes may not only have adverse effect for athletic performance but also increase the risk of injury in long term. This contrasts the evidence about the influence of fatigue on trunk muscles reflex activity.

Method: 37 athletes (men) were recruited from city soccer clubs. The participants performed sub maximal isometric exercise of lower back extensors (Ito's test) to induce fatigue. The two protocols were a single bout and repeated bouts of Lumbar Extension Isometric Exercise (LEIE). The Agility scores recorded at baseline, after single bout and after repeated bouts of LEIE were compared.

Conclusion: The two experimental interventions differently affected the agility performance in the sample. On one hand, single bout intervention led to improved performance, repeated bout intervention resulted in relative deterioration of performance.

Keywords: Paraspinal Fatigue, Athletic Performance, Lumbar Extension Isometric Exercise

Introduction

At high level of competition, sports require long periods of hard physical work and each athlete should be able to perform action as per the requirement of the respective sports with efficiency and accuracy. These activities not only require skill but considerable amount of strength, endurance and coordination. Athletes acquire demanding dynamic postures and perform movements going through extremes of ranges of motion putting considerable load on the musculoskeletal system. For instance a hockey player acquires position of thoraco lumbar flexion,[1] a position of eccentric loading of paraspinal muscles particularly that of the lumbo-sacral region, which must be dynamically sustained for most of the duration of a game. Similarly a soccer player is maneuvering the ball through the game; which warrants for explosive yet controlled motion achieved via coordinated activation of kinetic chain including muscles of the trunk and lower extremity to provide dynamic stability to complete the targeted action successfully. A fast bowler in cricket characteristically in one day international covered 16 km per game, with 12% of the time striding or sprinting and performed 66 sprints per game over 18 m and 1 high intensity run of ~3 seconds every 68 seconds, recording a maximum sprinting speed of 8.3 m/s.[2] A T20 cricketer covered 6.4-8.5 km per game, while sprinting 0.1-0.7 km during 80 minutes of fielding. Fast bowlers covered 8.5 km and sprinted 42 times typically over 17 meters. While batting for 30 minutes players covered 2.5 km and sprinted 12 times over 14 meters.[3] Preparing cricketers for various formats overall, ODI & T20 required 50-100% more sprinting/ hour than multi-day matches. The longer duration of multi-day matches resulted in 16-130% more sprinting per day, however shorter formats were more intensive per unit time, multi-day cricket has a greater overall physical load.[4]

Observations recorded in the literature illustrate those specific activities performed by the athletes lead to variations in the physical characteristic and require adaptation of training needs. A study at Australian institute of sports[1] observed the typical 'hockey players back' characteristically identified as a long relatively flat thoraco-lumbar region with some muscle asymmetry on right side. They also observed a general increase in range of rotation and frequent mild episode of LBP which responded rapidly to exercise and modification of training schedule. These changes are associated with heavy training involving repetitive cyclic loading of spine into flexion which is likely to cause fatigue of the para-spinal muscles, particularly in lumbo-sacral region. Those athletes with moderate to severe pains needed physical therapy but missed very few games as direct result of back pain.

Research in cricket bowlers and baseball pitchers has shown a correlation between workload and injury risk.[5,6]

A muscle imbalance[7] may itself be the cause or outcome of faulty technique but leads to compensatory overload on the paraspinal muscles making them vulnerable to fatigue. However mathematical modeling has cast some doubts on this assumption, with some suggestion that this asymmetry may reduce the stresses in the pars.[8]

Similar asymmetry of quadrates lumborum and psoas has been observed in Australian football league players.[9]

It is believed that postural muscles that can sustain prolonged contractions are less likely to fatigue and can thus continue to provide support to the torso, reducing the risk of injury or to maintain performance. Therefore, greater core muscle endurance should correspond with a greater capacity to work as indicated by the McGill's core strength tests which have reported reliability coefficients of 0.97.[10]

Scientific literature however does not offer a clear picture.[11] It is theorized that a strong core allows an individual the full transfer of forces generated from the ground through the lower extremities, torso and finally to the object via upper extremities.[12,13] A weak core is believed to cause alterations in the transfer of energy, resulting in reduced performance and increased risk of injury. Hence, the assumption that increase in core strength will result in increased sport performance leading to increased popularity of core training among strength coaches and trainers.

The studies that have examined core strength and sport-specific performance however were unable to establish a relationship between these variables.[14,15]

A few EMG fatigue studies have noted that artificially induced fatigue of lumbar paraspinal muscles leads to inhibition of knee extensors in an experimental setting.[16-20]

Even though it could not predict whether reduced quadriceps activation will be meaningful in an active setting as well, it has been speculated that these minor changes in quadriceps inhibition may indeed have cumulative effect on the performance or risk of injury over a competition, season, career or life time of an athlete.

EMG studies also observed that induction of fatigue to the lumbar paraspinal muscles results in increased postural sway. This has been seen in people with and without back pain. Researchers are also concerned that these minor variations as seen in studied population may have cumulative and greater effect on an athlete over a practice session, season or career.[21] Here it is interesting to see whether artificially induced fatigue to the lumbar paraspinal muscles by Ito test results in any real observable change in the athletic performance in terms of agility as could be anticipated with literature in context.

Materials and Methods

Sample

Thirty seven men (age=19.7568±1.27, weight=65.45±8.76 kg, height=1.73±0.056 meter) were recruited from the desired population according to the inclusion and exclusion criteria. A random sampling technique was used. The sample consisted of (n=37) athletes who played for various city soccer clubs. The criteria for inclusion in the study were having played soccer for at least 3 years and be in the age group of 18 to 22. The experimental procedure was explained to participants. They subsequently signed informed consent to participate voluntarily. The experimental procedure was approved by the institutional review committee of the Hamdard University and conducted at Hamdard University, JMC sports ground and Chhatrasal stadium.

Tools

Before starting the fatigue protocol, equipments required (inclinometer, stop watch, foam roll, straps and mat) were arranged and put in place. Field for outcome testing was prepared with the markers cones, paired t-test for statistical analysis.

Experimental Design

A pre-post experimental design comprised of two protocols of fatigue induction to the lumbar paraspinal musculature i.e. single bout Lumbar Extension Isometric exercise (LEIE-Image 1) and repeated bouts LEIE.

Performance Outcome Measure

The outcome measurement (Illinois agility test) was taken at baseline (P0), post single bout fatigue intervention (P1) and post repeated bouts fatigue intervention (P2). The agility scores at three levels were compared and analyzed using paired t-test.

The Protocol

On the first day, the participants were explained about the nature of the study and were given a demonstration of procedure. The participants were informed about possible risk, benefits of intervention and measure taken to ensure safety. All the possible questions and doubts which came to light were cleared on the same day. A thorough assessment was done and those fitting the criteria were included in the study. Willing participants signed an informed consent. The participants were free to discontinue being part of the study at any time if they so desired.

The experimental procedure had three sessions for each participant spread over a week with gap between sessions being at least 48 hours, the order of sessions was randomized and study completed over 4 weeks.

Before each session there was a period of warm-up. The protocol consisted of dynamic stretching exercises.[22]

Pre-Fatigue Session: warm-up followed by baseline measurement of athletic performance (agility) on session-1.

The Fatigue Protocol: Isometric back extension as illustrated in Image-1 held for maximum duration with 15° trunk inclination to the horizontal (monitored using Baseline digital inclinometer). Any deviation of ± 10° was announced by the examiner. Test was terminated if the inclination of trunk goes below 5° or beyond 25° in spite of best efforts by the participant.

Experimental Condition-1: Warm-up followed by single bout of isometric back extension held for maximum duration, followed by the performance measurement session.

Experimental Condition-2: Warm-up followed by repeated bouts of isometric back extensions held for maximum duration, repetition continues until complete failure or the participant refuse to take another repetition because of perceived exertion followed by the Post-intervention performance measurement.

The participant positioned himself on the mat and performs sub-maximal Lumbar Extension Isometric Exercise (LEIE) as demonstrated in the familiarization session (Image 1), holding it up at an inclination of 15° from the horizontal monitored using inclinometer (Baseline® digital inclinometer).

The examiner checked the optimal position of loading for lumbar paraspinal muscles and deviation of more than ±10° was announced which acted as feedback for the participant to improvise his efforts accordingly to maintain the targeted position. The participant is motivated to hold the position for as long as possible verbal cues.

Post-fatigue measurements were taken immediately after completing the fatigue protocol.

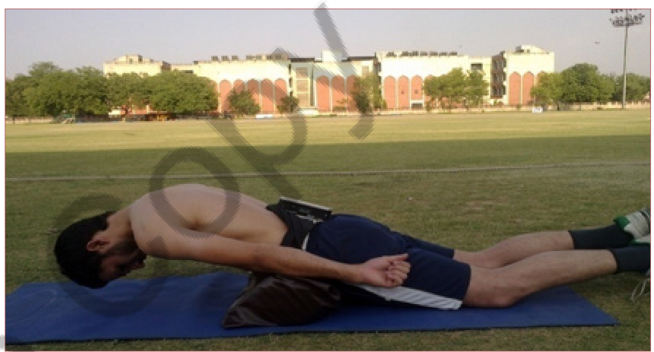

Image 1

Data Analysis

The data sets obtained at three levels of measurement were compared using paired t-test.

A 0.05 level of significance was used for all the comparisons. Value of confidence interval was set at 95%.

Result

The mean age of the sample 19.7568±1.27, years (range 18-22 years), mean height 1.73±0.056 meters and mean weight was 65.45±8.76 kg, mean BMI 21.76±2.36 kg/ m2.

The variability of data presented in Image 2, fatigue time (in seconds) - 1 [149.24±55.54 (P=0.766)] and fatigue time - 2 [473.86±122.21 (P=0.479)] observed within the sample was statistically insignificant.

The difference of means of the data sets at (P^o) baseline (18.024±1.4) and (P1) post single bout fatigue intervention (17.548±1.43) was found to be statistically significant, t=3.976 (p=0.000) but the difference of means of data sets at P0 (18.024±1.4) and P2 (post repeated bout fatigue intervention) (17.978±1.30) was not significant statistically, t=0.324, (p=0.748).

However the difference of means of data sets at P1 (17.548±1.43) and P2 (17.978±1.30) was statistically significant, t=-2.417, (p=0.021).

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This demonstrated a trend that the performance on Illinois agility test at P1 as an effect of single bout fatigue protocol improves significantly when compared to baseline. However after repeated bout fatigue intervention agility performance (P2) deteriorates relative to P1 and improvement relative to baseline (P0) is not statistically significant.

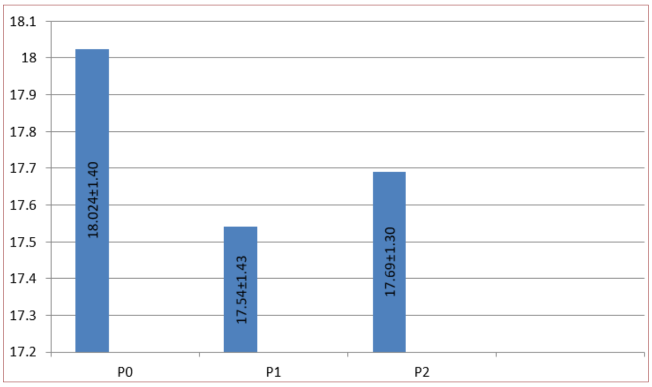

Image 2

Discussion

The results demonstrate that athletic performance is variably affected by the two experimental fatigue interventions. On one hand single bout of Lumbar Extension Isometric Exercise (LEIE) resulted in improvement of performance as the agility timings decreased. On the other hand repeated bouts of LEIE had no significant impact on the Illinois agility test timings relative to baseline whereas time taken increased relative to the post single bout intervention.

It is important to note that improvement of agility performance after single bout lumbar extensors isometric exercise is in contrast with quadriceps inhibition theory that fatigue of lumbar paraspinal muscles leads to quadriceps inhibition. However in further studies it is observed that quadriceps inhibition observed in their studies may not hold good for athletes due to their training and conditioning to challenges they encounter in sports on day to day basis.[17-20]

This improvement in performance could however be explained and is in concurrence with following evidence. Enoka[23] reported that when the task requires a sub maximal contraction, the onset of fatigue is probably not associated with the termination of the task. As most activities of daily living involve sub maximal forces, the onset of fatigue may not limit the ability of an individual to perform a task; furthermore failure may not be caused by fatigue of the principal muscles involved in the task. Here therefore it could be rationalized that the termination of the lumbar isometric extension task was because of reasons other than fatigue, thus no quadriceps inhibition took place.

This improvement in performance could have been due to failure of experimental protocol-1 to cause fatigue but rather leading to activation of core muscles, active warm up effect increasing the nerve conduction velocity leading to activation of the lumbar paraspinal muscles improving the proprioception and kinesthetic ability,[24] increasing the voluntary neuromuscular control in the lower back region allowing appropriate postural adjustments, providing proximal stability while allowing controlled distal mobility[25] improved biomechanical strategies coupled with learned responses and ability to anticipate change,[26] which leads to enhancement of agility performance.

This type of core activation and pattern of force development from the ground through the core to the extremity has been shown in base ball[27] and kicking activities.[28]

The improvement in performance could also be supplemented by idea of pre-activation in case of small postural adjustments or activation of large functional reflexes in response to large perturbations with increased amplitude and probably shortened temporal response.[29] This faculty would be better developed in athletes as compared to general population. Therefore the laboratory observed quadriceps inhibition may not be relevant in active setting, particularly in athletic population as reflex adaptations may help them counterbalance the minor changes that could have been caused by fatigue and consequent quadriceps inhibition.

Increased Soleus motor neuron pool excitability following lumbar paraspinal fatigue in people with or without history of low back pain occurred in the absence of changes in vastus medialis or fibularis longus muscles.[21] Increased soleus motor neuron pool excitability might be a postural response to preserve lower extremity function and thus no negative effect but enhanced performance post single bout fatigue intervention.

The statistically non significant differences of agility scores at baseline and after repeated bout fatigue intervention and deterioration of performance relative to single bout intervention indicated that fatigue might actually have started to set in superseding the potential activation effect achieved after the single bout experimental intervention. This also strengthens the possibility that single bout intervention was insufficient to induce fatigue. EMG measure of fatigue could have better answered this question.

The relative deterioration in performance after repeated bouts of lumbar extension isometric exercise compared to single bout intervention is not a sufficient condition to make a statement consistent with the findings of JM hart[17,20] as the average score were still better than the baseline. The repeated bout intervention managed to induce fatigue to some extent however trend indicates that adequate fatigue could have produced further decrement in agility scores.

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Conclusion

The single bout lumbar extension isometric exercise acts as performance enhancer resulting in improved agility and may help athletes prepare and perform better. Whereas repeated bout intervention till fatigue holds potential to be a limiting factor for athletic performance, however same could not be effectively concluded from the study.

Limitations

Objective quantification of fatigue could not be done.

Though minimum experience criteria in sports were set to 3 years no maximum limit was set.

Precision in outcome measurement by use of timing gates for agility would have given more clarity in results and eliminated examiner reaction time lag.

Ethical approval/ Informed Consent

The study was pre-post experimental design comprised of two protocols of fatigue induction to the lumbar paraspinal musculature for which prior consent of participants had been taken.

Financial Disclosure

There are no financial conflicts of interest to disclose.

Conflicts of Interest: None

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