THE RELEVANCE OF THE HIP EXTENSOR MUSCLES TO LOW BACK PAIN IN ELITE FEMALE FIELD HOCKEY PLAYERS

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ABSTRACT: *Low back pain (LBP) is a common complaint among field hockey players. Only a few of the risk factors for LBP have however been assessed on these players. These include trunk strength and lumbosacral range of motion. The aim of the literature review was therefore to investigate the reports of LBP among elite female field hockey players, focusing on risk factors for LBP, biomechanical aspects of field hockey, muscle imbalance and the role of the gluteus maximus (GM) muscle in the development of LBP. The literature indicated a strong link between LBP and GM weakness. More recent research supports this concept and clearly stated that female athletes with GM weakness are at risk for the development of LBP. Considering that the biomechanical aspects and unique requirements of field hockey indicate hip extensor involvement, as well as the association between LBP and GM weakness, further investigation is warranted into the hip extensor muscles of field hockey players.*

KEY WORDS: LOW BACK PAIN; HIP EXTENSORS; FEMALE FIELD HOCKEY; MUSCLE IMBALANCE.

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INTRODUCTION

A review of the literature on field hockey indicated that despite the popularity of the sport, only a few studies have been conducted to attain more information about the injury patterns and risk factors for injuries. Regarding low back pain (LBP) Murtaugh (2001) established that 59% of field hockey players studied experienced back pain, mainly of the lower back. Furthermore there is a strong indication in the literature that weakness of the hip extensor muscles plays an important role in the development of LBP (Janda 1986; Kankaanpää et al. 1998; Leinonen et al. 2000; Nadler et al. 2000, 2001). Recent research suggests the screening of hip extensor strength in the prevention of LBP in female athletes (Nadler et al. 2000, 2001).

The aim of this literature review was therefore to investigate the reports of LBP among elite female field hockey players. This overview of the literature considers LBP among field hockey players, focusing on risk factors for LBP, biomechanical aspects of field hockey, muscle imbalance and the role of the gluteus maximus (GM) muscle in the development of LBP. The article is concluded by a discussion of the clinical relevance and implications of the findings of the review.

LBP AMONG FIELD HOCKEY PLAYERS

The study by Murtaugh (2001) highlighted the occurrence of LBP and is supported by previous studies documenting 53% (Reilly & Seaton 1990) and 78% (Lindgren & Twomey 1988) of hockey players suffering from LBP. Other studies however report a lower incidence of LBP: 5% (Petrick et al. 1992), 9.4% (Watson 1997) and 8.9% (Fuller 1990) of the total injuries. This apparent controversy in the literature could be due to the following differences in methodology:

1) Different methods of data collection (survey versus direct reporting). In most of the studies with higher prevelance, injuries were self reported and relied on the athlete's ability to accurately recall his/her injuries (Lindgren & Twomey 1988; Murtaugh 2001). Fuller (1990), Petrick et al. (1992) and Watson (1997) improved on this by doing prospective studies on injury patterns.
2) Inconsistent variables, i.e. the level of experience, the surface hockey is played on, age, sex, etc. Stevenson et al. (2000) states that it is to be expected that injuries will differ among professional, elite and social players.
3) Varied definitions of injuries and classification of the degree of injury (severe, moderate, minor).

Results of studies should be seen in the context within which the particular study was conducted and therefore caution must be taken to generalise the data regarding LBP across studies.

RISK FACTORS FOR LBP

When considering LBP among field hockey players, it is important to take into account risk factors of LBP, as well

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as recent changes in the game. The speed of field hockey has increased due to several factors, securing constant involvement of all players on the field, thus minimising their recovery period. Since 1996 field hockey has undergone certain rule changes, including the change of the offside rule and regular substitution of players. Elite players now practise and play on synthetic surfaces, necessitating the player to maintain a much lower body position in order to achieve better skill during stopping, flicking and tackling. These changes might be seen as a risk factor to the development of LBP due to the effect on the musculoskeletal system. In view of the relevant changes of the game and their influence on the posture of the hockey player, it is questionable whether previous studies still represent what is currently applicable to the game. Taking this into account, the source of information concerning injuries in the sport is limited and highlights the need for current data on field hockey.

Several risk factors for LBP have been reported in the literature: decreased flexibility of the hip flexors, hamstrings and/or rectus femoris (Biering-Sorenson 1984; Fairbank et al. 1984); leg length discrepancy (Giles & Taylor 1981); sacroiliac joint dysfunction (Indahl et al. 1999; Schwarzer et al. 1995); reduced trunk strength (McNeill et al. 1980); acquired ligament laxity and/or overuse injury of the lower extremity (Nadler et al. 2000) and reduced lumbosacral range of motion (ROM) (Mayer et al. 1984).

Only a few of these risk factors for LBP have been assessed on field hockey players. Reilly & Seaton (1990) highlighted the unique stress of field hockey on the spine. They established that seven minutes of dribbling a hockey ball could cause an average spinal shrinkage of 2.73mm and that dribbling can increase energy expenditure from normal running by 15-16 kJ min^{-1}. They concluded that the physiological strain and spinal loading distinctive to field hockey are most likely due to the peculiar postural requirements of the game.

Fenety & Kumar (1992) investigated trunk muscle strength and spinal mobility as risk factors for LBP in elite female field hockey players. Their results indicated that hockey players with LBP had:

- weaker peak and average eccentric extension trunk strength compared to the control group;
- significant loss of lumbosacral extension and total lumbosacral ROM compared to pain-free hockey players and the control group; and
- no significant difference in lordosis from the control group.

It was concluded that female hockey players, regardless of the occurrence of LBP, are at risk of reduced lumbosacral ROM and trunk extension strength. These results are however not entirely supported by earlier research. Lindgren & Twomey (1988) found elite hockey players to have:

- strong trunk extensors and flexors;
- no obvious relationship between lumbar ROM and LBP and
- a long, flat thoracolumbar spine, with some muscle asymmetry on the right.

The controversy in the above two studies could be due to differences in measurements of outcome. Fenety & Kumar (1992) used photographs for ROM measurement on female players, while isokinetic testing of the trunk muscles was conducted throughout the functional range required to play field hockey. This was an improvement on the single position isometric test, as well as lumbar spondylometer and rotameter used by Lindgren & Twomey (1988) on male and female players. Gender specific differences are noted elsewhere in the literature (Nadler et al. 2000), indicating a significant side-to-side hip extension strength difference among females but not males. This could contribute to differences in results.

The hip extensor muscles are another possible contributing factor to LBP in field hockey players. Fenety & Kumar (1992) suggested hip extensor strength testing as part of the functional assessment of field hockey players. Considering the hip musculature, Porterfield & DeRosa (1998) stated that the muscles from below (muscles of the hip and knee joint) and the muscles above the pelvis (muscles of the lumbar spine and abdominal wall) are responsible for proper reduction of forces through the lumbar spine. The powerful hip muscles cross the sacroiliac joint and are mechanically linked to the muscles of the lumbar spine, thus they are able to influence the lumbopelvic area (Porterfield & DeRosa 1998). The thoracolumbar fascia functions as this mechanical link and according to Vleeming et al. (1995) plays an integrated role in trunk rotation and load transfer within the kinetic chain. The fascia is tensed by contraction of various muscles, including the latissimus dorsi, GM and erector spinae (ES), contributing to stability of the lumbar spine and pelvis (Vleeming et al 1995). With decreased muscle strength of any of these muscles, the efficiency of the posterior layer will be affected, decreasing force closure and therefore stability of the lumbar spine and sacroiliac joint (Vleeming et al 1995). Vogt et al (2003) suggested that changes in the recruitment pattern of the hip extensor muscles are a factor in the development of LBP. Nadler et al. (2000) confirmed this by stating that poor hip muscle control may increase an individual's risk for the development of LBP. The authors argued that the transfer of forces from the lower extremity to the spine is jeopardised. All these factors reinforce the association between the hip muscles and the lumbar spine. It must however not be seen in isolation from the biomechanical requirements of field hockey.

BIOMECHANICAL ASPECTS OF FIELD HOCKEY

A review of the biomechanical aspects of the game, including the sustained posture and repeated movements, indicates the possibility of hip extensor muscle imbalance.

Posture

Field hockey is a game with an inbuilt asymmetry. Sticks are designed for right-handed use and the rules require that only one side of the stick may be used. Ball-handling skills such as dribbling, hitting, flicking and pushing are executed in a position of spinal and hip flexion, requiring considerable muscle strength and endurance. Fox (1981) described this position as an ergonomically unsound posture for fast controlled locomotion due to the spinal flexion demand of the game. This semi-crouched position must be sustained for the best part of the game, lasting 70 minutes, and for the greater part of a two-hour training session for elite players (Lindgren & Twomey 1988).

Karlsson & Jonsson (1965) and Marzke et al. (1988) confirmed GM recruitment as a hip extensor during a crouched (squatting) position, controlling flexion and rotation of the trunk on the femur. Marzke et al. (1988) further highlights GM involvement in activities where the trunk is used for leverage to increase the force and velocity to hand-held tools. These aspects describe biomechanical components of field hockey. In addition, the ball is hit and pushed with force during play. Therefore the unique postural requirements of the game necessitate considering the lumbar spine and surrounding muscles, and the muscles around the hip, especially the hip extensor muscles.

Repeated movements and sustained postures

Sahrmann (2002) states that repeated movements and sustained postures can change a muscle(s) strength and length, eventually changing the movement pattern, thus causing impairment. This confirms the risk of the hip extensor muscles in field hockey players. It has to be realised that even athletes are at risk for undesirable changes in movement components, resulting in the development of movement impairments, tissue stress, microtrauma and eventually macrotrauma (Sahrmann 2002). Taking into account the role that the GM plays during hockey, it could easily be assumed that it would be adequate to strengthen the muscle. However, considering the work by Janda (1978) and Sahrmann (2002), this muscle is prone to weakness and the repeated movements could lead to adaptation of the GM muscle length and strength, thus affecting the movement pattern (delayed timing or recruitment deficiency). These changes could eventually contribute to a muscle imbalance, especially around the hip. It is also uncertain whether or not the asymmetry of the sport results in asymmetry of lower extremity muscle strength.

MUSCLE IMBALANCE

As far back as 1978, Janda defined muscle imbalance as an impaired relationship between muscles that are prone to develop tightness and shortness and muscles that are prone to inhibition and weakness. Muscle imbalance can manifest as differences between side-to-side (right versus left), the agonist-antagonist (Grace 1985) or synergists (Sahrmann 2002). The suggestion has been made that this muscle imbalance must not be viewed in isolation from movement patterns (Richardson et al. 1999; Sahrmann 2002; Schlink 1990). From the literature it is evident that the movement patterns are investigated by assessing the:

- muscle recruitment/firing order, thus the timing/onset of activation (Hodges & Richardson 1996; Pierce & Lee 1990; Richardson et al. 1999, 2000); and/or
- muscle activity, thus the level of contribution described as a percentage of maximum voluntary isometric contraction (MVIC) (Richardson et al. 2000; Souza et al. 2001).

Pierce & Lee (1990) suggested that there might be a link between these two aspects, for changes in muscle recruitment order may be due to changes in EMG muscle activity.

According to Janda (1978) and Sahrmann (2002) the GM is prone to weakness and the hamstring prone to tightness. Weakness of the GM results in increased activity of the thoracolumbar ES and hamstring during hip extension, thus abnormal muscle activity (Schlink 1990; Vogt & Banzer 1997). With regards to muscle firing order, GM recruitment is often delayed; taking place at the end of hip extension, after an abnormal lumbopelvic position or an anteverted pelvis and hyperlordotic lumbar spine has been achieved (Schlink 1990). This poor hip muscle control may jeopardise the transfer of forces from the lower extremity to the spine (Nadler et al. 2000). This may explain why Singer (1986) advocated that lumbar assessment include the evaluation of muscle firing order of the hip extensor muscles during active prone hip extension (APHE). Contradicting this proposal, a study by Pierce & Lee (1990) indicated that there is no 'consistent' firing order of the hip extensors among healthy subjects without any LBP history. However, a more recent study investigating APHE from neutral showed a more consistent muscle firing order of ipsilateral ES, semitendinosus, contralateral lumbar ES, tensor fascia latae and GM (Vogt & Banzer 1997). This discrepancy could be due to the difference in chosen ROM. According to Vogt & Banzer (1997) APHE from 30° (hip flexion to neutral) (Pierce & Lee 1990) excludes any accompanying movement of the trunk and may therefore not be directly comparable to APHE that starts at neutral.

The question now arises whether the muscle firing order and/or muscle activity of healthy subjects participating at a high level of the same activity would be any different from the previous studies? Mayer (1987) suggests that athletes training in a physically demanding sport deserve being compared to a sport-specific database. Sport played at a high level contributes to adaptation specific to that sport, which will not necessarily be the case in sedentary individuals. Differences in strength of synergists could be contributed to a specific sport (Sahrmann 2002). The posture hockey is played in, and the fact that the muscles around the hip are functioning in a closed kinematic chain, contributing to the distribution of forces up the spine, warrants further assessment. The strength and endurance of the hip extensor muscles can indirectly influence the lumbar spine (Nadler et al 2000).

The kinetic chain

According to the kinetic chain or link theory of Nicholas et al, as far back as 1977, muscle imbalance cannot be seen in isolation. The lower extremity kinetic chain functions as a unit, implicating that any change in the unit will have repercussions on the rest of the unit. Any lower extremity injury or dysfunction will therefore have implications on the rest of the kinetic chain. Several more recent studies support this finding (Beckman & Buchanan 1995, Bullock-Saxton 1994). The theory is further reinforced by research supporting the proposed link between muscle imbalance, lower extremity injuries and/or LBP in athletes (including sport such as volleyball, soccer, swinning, track, tennis, basketball) (Knapik et al. 1991; Nadler et al. 1998, 2000, 2001). The kinetic chain theory therefore reinforces the association between the hip musculature and lumbar spine and confirms the relevance of the hip muscles in the development of LBP. Research specifically indicates an association between female athletes with significant asymmetric hip extensor muscle strength and the development of LBP (Nadler et al 2001).

Dysfunction in the kinetic chain is therefore a complex interaction of the articular, muscular and neural systems. When considering the link between the GM and LBP in the lumbo-pelvic hip complex, the effect of inappropriate recruitment of movement synergists around the hip should be considered. According to Sahrmann (2002) even athletes are at risk for muscle imbalance between synergists: one muscle being notably weaker than its synergist. EMG studies by Sahrmann (2002) indicate that extreme variation from the normal recruitment patterns and timing of synergists may contribute to imbalance within force couples. If one muscle is dominant and contributes more force to a particular movement (e.g. hamstring instead of GM in APHE), then the other muscle(s) are required to contribute less, leading to impairment of the less dominant muscle (e.g. GM). Delayed recruitment of the less dominant muscle can be reflected in decreased muscle strength. Therefore, the susceptibility of the dominant muscle for an overuse syndrome (e.g. hamstring) increases. Sahrmann's (2002) assessment of movement patterns therefore considers the muscle firing order (e.g. delayed GM recruitment) and muscle activity (e.g. GM contributing less force to the movement).

Gluteus Maximus and Low Back Pain

Janda's (1986) speculation about reduced GM activity in patients with LBP is supported by recent studies. Kankaanpää et al. (1998) and Leinonen et al. (2000) demonstrated poor endurance of the GM in patients with chronic LBP. Vogt et al. (2003) suggested that the role of the GM and hamstring muscles are often overlooked in the development of pain syndromes in the lumbar/sacral/hip region. Nadler et al's (2000, 2001) research adds validity to the association between hip muscle imbalance and LBP among female athletes. Results demonstrated a significant difference in GM muscle strength in female athletes with LBP compared to athletes without LBP ($p = 0.04$). The results support the proposal that GM muscle imbalance can contribute to the transmission of abnormal forces up the kinetic chain to the spine, increasing the risk for the development of LBP.

CLINICAL RELEVANCE AND IMPLICATIONS

Injury prevention

It remains a challenge for physiotherapists to use effective pre-season musculoskeletal assessment to identify any existing muscle imbalance, so that rehabilitation can attempt to prevent injuries. Research into this area will provide a much-needed emphasis shift from injury treatment to injury prevention. If corrected, the athlete can return to the sport unrestricted, rather than ending up with a chronic condition due to a muscle imbalance (Schlink 1990). Grace (1985) states that if a muscle imbalance is recognized and corrected, it could hypothetically decrease the incidence of athletic injury.

Assessment of muscle imbalance

It is imperative that physiotherapists, working with athletes, know whether a muscle imbalance is a specific adaptation to that sport. Previously, decreased muscle activity was considered to be muscle weakness, without questioning the cause. The resulting weakness could be due to altered movement patterns, i.e. due to changed motor regulation and motor performance (Janda 1986; Richardson et al. 1999). Janda (1986) suggests that movement patterns must be assessed for a changed muscle firing order due to delayed muscle activation (the non-inhibited synergists usually become activated earlier) and/or decreased activity of a specific muscle. This is in agreement with what Richardson et al. (1999, 2000) is implementing during assessment of the trunk musculature. The focus is therefore on the muscle firing order and/or muscle activity during movements using EMG.

This proposal supports a focus change from the actual muscle weakness to the movement pattern (muscle activity and muscle firing order). Although muscle testing identifies any deficit as a result of weakness and length changes, it does not give information about poor motor control, and therefore manual muscle testing of the synergists, as well as observation of movement patterns have to be used to support the hypothesis of altered recruitment patterns (Sahrmann 2002). Weakness of the one synergist should be consistent with inadequate participation of this non-dominant synergist. The dominant synergist is then susceptible to an overuse injury (Sahrmann 2002). Schlink (1990) states that poor quality of movement and substitution or compensatory patterns will portray the presence of muscle imbalance and direct treatment better. The above implies that in hockey players one should test the muscle strength of the GM and hamstring muscle using for example manual muscle testing (according to Kendall 1993), kinetic control testing (Comerford, Mottrom & Gibbons 2005) or isokinetic testing (if the facilities are available). In addition the movement pattern of hip extension in prone should be assessed. Weak GM will be confirmed with increased activity of the hamstring and ES, as well as possibly an increase in the lumbar lordosis. This can be done visually or using EMG if available. EMG and isokinetic testing is not readily available to most clinicians. Though, the innovative kinetic control testing described by Comerford, Mottrom & Gibbons 2005 allows for testing muscle strength and movement patterns efficiently and objectively in everyday clinical practice.

The need for more data

Studies by Nadler et al. (2000, 2001) supported the screening of hip extensor strength, as it may be significant in the prevention of LBP in female athletes. The role of the hip extensors has not been specifically assessed in female field hockey players. Mayer (1987) has identified the lack of a sport-specific database for athletes training in a physically demanding sport. There is a need to establish a baseline reference as prerequisite for future clinical studies of female field hockey players with LBP or other injuries. The baseline data can be added to the research that has been completed on female field hockey players, including isokinetic trunk strength and endurance, as well as sagittal and horizontal lumbar ROM (Fenety & Kumar 1992; Lindgren & Twomey 1988). In addition, it must be realised that assessment of apparently healthy athletes can reveal specific deficiencies in flexibility or muscle strength, which may predispose the athlete to injury (Agre & Baxter 1987) and can assist during the rehabilitation of the injured athlete (Alexander 1990). It is thus imperative that baseline data is obtained specific, relevant and functional to that sport.

SUMMARY

Despite the high incidence of LBP among field hockey players, only a few of the risk factors predisposing LBP have been assessed in this population. The posture a player adapts playing hockey causes unique stresses on the musculoskeletal system, especially the hip extensor muscles. This can lead to changes in the muscle and movement pattern, thus causing injury. The link between LBP and GM weakness is well documented throughout the literature (Janda 1986; Kankaanpää et al. 1998; Leinonen et al. 2000; Nadler et al. 2000, 2001). This however, has not been considered as a risk factor for the development of LBP among field hockey players. Baseline data on the hip extensor muscles of female field hockey players can be used for further clinical studies on female field hockey players with LBP or lower extremity injuries. This will assist in identifying risk factors for the development of LBP, aiding the physiotherapy profession to function preventatively, and not only curatively. The detection of muscle imbalance as a risk factor is very important and needs to be assessed specific to the sport.

Considering that GM imbalance may be a predisposing factor to the development of LBP due to the transmission of abnormal forces to the spine (Nadler et al. 2001), and that the hip muscles play a significant role in transferring forces from the lower extremity up to the spine (Porterfield & DeRosa 1998), the hip extensors of field hockey players warrants further investigation towards prevention of LBP in this population group.

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