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Pattern of muscle injuries and predictors of return-to-play duration among Malaysian athletes

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INTRODUCTION The purpose of this study was to investigate the pattern of muscle injuries and the factors that predict the return-to-play duration among Malaysian athletes.

METHODS This is a retrospective review of the case notes of athletes who attended the National Sports Institute Clinic in Malaysia. The medical records of athletes with muscle injury, diagnosed on clinical assessment and confirmed by diagnostic ultrasonography, were included for final analysis.

RESULTS From June 2006 to December 2009, 397 cases of muscle injury were diagnosed among 360 athletes. The median age of the athletes with muscle injuries was 20.0 years. Muscle injuries were mostly diagnosed among national-level athletes and frequently involved the lower limb, specifically the hamstring muscle group. Nearly all of the athletes (99.2%) were treated conservatively. The median return-to-play duration was 7.4 weeks. Athletes who waited more than one week before seeking medical attention, those with recurrent muscle injuries and female athletes were significantly more likely ($p < 0.05$) to take more than six weeks before returning to the sport.

CONCLUSION Grade 2 lower limb muscle injury was commonly diagnosed among national-level athletes in this study. The frequency of weekly physiotherapy sessions did not affect the return-to-play duration. Factors such as initial consultation at more than one week post injury, recurrent muscle injuries and female gender were significant predictors of return-to-play duration among Malaysian athletes. These predictive factors should be kept in mind during clinical assessment so as to aid in prognosticating recovery after muscle injury.

Keywords: athletes, Malaysia, muscle injury, musculoskeletal, return to play

INTRODUCTION

Muscle injury is one of the most common injuries affecting athletes.(1) It accounts for up to 28% of injuries in sports events.(2) Contusion and strain are two common causes of muscle injuries. Muscle strain often occurs during sprinting or jumping, when the muscle is under tension while lengthening (eccentric contraction).(3) Earlier studies have identified several factors that predispose one to muscle injury, including a history of muscle strain, increasing age and leg dominance.(4-6) Muscle injuries often occur at the muscle-tendon (myotendinous) junction of muscles that span across two joints, such as the rectus femoris, semitendinosus and gastrocnemius. Diagnosis and grading of muscle injuries are usually done through clinical assessments.(2) Ultrasonography (US) is recommended for localising injury and characterising severity of injury.(7)

In professional sports, muscle injuries can lead to significant pain and disability, resulting in time away from participation (training and competition) and high medical costs.(8) Athletes and coaches are often concerned about the time to full recovery and return-to-play (RTP). Unfortunately, issues on duration to return-to-play (DRP) are often not directly discussed during consultation with the medical team.(9) Predicting DRP is not only important for planning the rehabilitation programme, but also for enabling the coaching staff to restructure the team for competitions.

Recent studies have identified several factors that may help in estimating DRP.(6,10,11) An observational study of 59 players from ten Victoria-based Australian Football League clubs showed that the time taken for an athlete to walk pain-free after a hamstring injury was a significant predictor of time to RTP.(12) That study, however, did not discuss the severity of the muscle injury sustained and give details of the rehabilitation programme. In addition, a prospective study among athletes with grade 1–4 hamstring injuries suggested that active knee range of motion deficit was an objective and accurate measurement in predicting DRP.(11)

Information on the pattern of muscle injuries among Malaysian athletes is limited.(13) Differences in physical build, climate, dietary intake and training regimen between Malaysian and foreign athletes may affect muscle injury pattern. Identifying the pattern of muscle injuries, including the magnitude of the problem, is an important initial step in injury prevention programmes.(14) However, there is no information on the current management of muscle injuries and the effectiveness of treatment (e.g. DRP) among Malaysian athletes. Hence, the aim of this study was to examine the pattern of muscle injuries and explore the predictors of DRP among Malaysian athletes.

METHODS

A retrospective study using data extracted from athletes' medical records was conducted at the National Sports Institute Clinic, Kuala Lumpur, Malaysia. A structured form was prepared to record the sociodemographic background of the athletes and clinical information of their injury. All of the athletes were

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under the care of sports medicine specialists. A visiting musculoskeletal radiologist with 14 years of experience performed all of the US assessments. US was conducted using an ACUSON Antares™ Ultrasound System (Siemens AG, Erlangen, Germany) with a 4-cm linear transducer set at 10 MHz. Severity of muscle injury was graded based on the US classification described by Peetrons.[15] The University of Malaya Medical Centre Ethics Committee approved the study.

The US registration records from June 2006 to December 2009 were reviewed. The medical records of athletes diagnosed with muscle injuries on US were evaluated. Information on the athlete's age, gender, playing level (school, club, state or national) and type of sport was collected. Information on injuries, including date of injury, date of first consultation, event leading to injury (training session or competition), injury severity and date of RTP, was also recorded. Pattern of muscle injuries, including injury severity, region of injury and event leading to injury, was reviewed. DRP following muscle injury was recorded. DRP was defined as the difference (in weeks) between the date on which the attending doctor allowed full participation in sports and the date of onset of injury.

Data was analysed using the Statistical Package for the Social Sciences version 19.0 (SPSS Inc, Chicago, IL, USA). Data was described descriptively and a normality test was performed using the Shapiro-Wilk test. DRP < 6 weeks was used as the cutoff value for adequacy of DRP – this definition was based on a recent systematic review of muscle injury by Prior et al,[16] and supported by the results of another study, where athletes whose DRP was > 6 weeks after muscle injury were found to have a significantly lower chance (3.1%) of sustaining repeat injury compared to those who resumed sports at 2 weeks (8.1%) or 3 weeks (6.8%) post injury.[17]

The associations between DRP and gender; age group (≥ 18 vs. < 18 years); and duration before first consultation (≤ 1 vs. > 1 week) were assessed using Mann-Whitney *U* test. Kruskal-Wallis test was used to determine the association between DRP and type of sport; frequency of weekly physiotherapy sessions; playing level (school, state, national or others); new vs. recurrent injury; region of injury (upper limb, lower limb or truncal muscles); and US grading of injury (grade 0–3). Stepwise logistic regression analysis was conducted to identify the predictors of DRP. Variables < 0.25 on univariate testing were included in the multivariate logistic regression model, as recommended by previous researchers.[18,19] Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) of ORs were calculated, with the significance level set at $p < 0.05$.

RESULTS

A total of 562 medical records of athletes with suspected muscle injuries were screened. Of these, 202 medical records were excluded from analysis for the following reasons: incomplete medical information (n = 25); missing US report (n = 75); and injuries involving structures other than muscles (i.e. ligaments and tendons) (n = 102). Only 360 medical records (237 men and 123 women) were eventually analysed. Among these 360 athletes, 397 muscle injuries were diagnosed. The majority (60.6%) of muscle injuries were classified as a new injury. The median age of the athletes at the time of injury was 20.0 (interquartile range [IQR] 6.0) years.

Most injuries (90.0%) occurred among national-level athletes participating in various sports – track and field (30.3%), field hockey (17.8%), racket sports (11.4%), martial arts (6.7%), soccer (5.3%), weightlifting (5.0%), gymnastics (4.7%), swimming (4.2%) and others (14.4%). Injuries were frequently diagnosed in muscles of the lower limb, especially the hamstring and adductors muscle groups (Table I). Athletes with a primary complaint of lower back pain (n = 29) were clinically assessed, and plain radiography of the lumbosacral region was performed to rule out any bony pathology. Magnetic resonance (MR) imaging was performed in three cases, as the clinical assessments led to suspicions of neurological involvement; this was in accordance with the clinical practice guidelines by the American College of Physicians and American Pain Society.[20] MR imaging was unremarkable in two athletes, while a sacrospinalis tear was demonstrated in the third. All athletes subsequently underwent US assessment of the lumbosacral region using a simple grading system for severity.[15,21]

The median time to first consultation was 7.0 (IQR 12.0) days after injury, and the median time before US evaluation was 17.0 (IQR 29.0) days. Out of a total of 397 muscle injuries, grade 2 muscle injury was diagnosed in 368 (92.7%) athletes, grade 1 in 26 (6.5%) and grade 3 in 3 (0.8%). Most (93.9%) injuries occurred while the athletes were performing sports-related activities, with the majority (82.5%) occuring during training or practice sessions. A large number of track and field athletes (69.7%) sustained muscle injuries during sprinting; the injuries occurred less frequently during jumping (13.8%) and weight training (5.5%). Similar results were observed among the field hockey athletes, whose muscle injuries occurred primarily during sprinting (75.0%). In contrast, approximately 40% of the racket sport athletes sustained injury during jumping activities (e.g. jumping smash).

Nearly all athletes (99.2%) were treated conservatively (i.e. nonsurgical intervention). Most (66.4%) received a short course (< 1 week) of analgesia (e.g. nonsteroidal anti-inflammatory drugs) combined with at least one form of electrotherapeutic modality. Only three athletes with complete muscle rupture underwent surgical intervention. Documented dates of RTP were available for only 168 athletes, while that for the remaining 192 athletes were unavailable as they were lost to follow-up. Approximately 40% (n = 67) of athletes were allowed full RTP within six weeks after injury. DRP ranged from 1 to 72 weeks, with a median of 7.4 (IQR 8.5) weeks. No significant differences in DRP across the type of sport ($H(26) = 25.32$, $p = 0.50$) and frequency of weekly physiotherapy session

Table I. Muscle injuries (n = 397) according to body region.

Body region/muscle group	No. (%)
Lower limb	
Hamstring	145 (36.5)
Adductor	43 (10.8)
Calf	49 (12.3)
Quadriceps	31 (7.8)
Others*	11 (2.8)
Upper limb	
Deltoid	15 (3.8)
Biceps	6 (1.5)
Triceps	4 (1.0)
Rotator cuff	15 (3.8)
Others†	35 (8.8)
Abdomen	
Rectus abdominis	12 (3.0)
Others‡	2 (0.5)
Back	
Muscles of the back§	29 (7.3)

*Anterior tibialis, posterior tibialis, peroneal muscles; †Pectoralis, rhomboids, small muscles of the hand; ‡External obliques, transversus abdominis; §Erector spinae, quadratus lumborum

(H(3) = 0.44, p = 0.93) were found. In most cases, a physiotherapy session typically started with range of motion exercises (stretching), followed by progressive muscle strengthening activities and cryotherapy at the end of the session. In addition, the treating physiotherapists often incorporated various electrotherapeutic modalities during these sessions. Further analysis revealed that athletes who were lost to follow-up were significantly older ($U = 13197$, $z = -3$, $p = 0.03$).

A moderate, significantly positive relationship was found between time to first consultation and DRP ($U = 2023$, $p < 0.001$). A significant relationship between DRP and muscle region (limb versus trunkal) was also demonstrated ($\chi^2 = 6.8$, $p = 0.04$) (Table II).

Gender, time to first consultation, injury type (new vs. recurrent), injury severity, number of injured muscles and side of injury were factors that met the criteria for inclusion in the multivariate model. Delay in first consultation of more than one week, recurrent muscle injuries and female gender were identified as predictors of DRP of > six weeks (Table III). No interactions were noted between the predictors. All other variables were eliminated by the stepwise procedure.

Table II. Factors associated with duration to return-to-play among patients with documented date of return-to-play (n = 168).

Factor	No. (%)	U*/χ^2 †	p-value
Gender*		2,898	0.23
Male	107 (63.7)		
Female	61 (36.3)		
Age group (yrs)*			
< 18	52 (31.0)	2,730	0.32
≥ 18	116 (69.0)		
Time to first consultation (wk)*			
≤ 1	91 (54.2)	2,023	< 0.001
> 1	77 (45.8)		
Injury type*			
New	104 (61.9)	2,908	0.17
Recurrent	64 (38.1)		
Injurious event*			
Traumatic	10 (6.0)	646	0.34
Nontraumatic	158 (94.0)		
Injury grade (via US)*			
Grade 1	12 (7.1)	681	0.12
Grade 2	156 (92.9)		
No. of muscles injured*			
1	147 (87.5)	1,144	0.07
2	21 (12.5)		
Activity leading to injury†			
Training	140 (83.3)	0.69	0.71
Competition	26 (15.5)		
Others	2 (1.2)		
Affected side†			
Right	73 (43.5)	3.50	0.18
Left	84 (50.0)		
Bilateral	11 (6.5)		
Affected region†			
Upper limb	31 (18.5)	6.8	0.04
Lower limb	121 (72.0)		
Truncal	16 (9.5)		
Level of play†		0.24	
National	155 (92.3)		0.97
State	3 (1.8)		
School	7 (4.2)		
Others	3 (1.8)		
Physiotherapy session†			
Daily	119 (70.8)	0.60	0.90
Weekly	22 (13.1)		
Twice a week	21 (12.5)		
Thrice a week	6 (3.6)		

*Mann-Whitney *U* test †Kruskal-Wallis test
US: ultrasonography

DISCUSSION

In this study, grade 2 muscle injury was the most common form of injury diagnosed among national-level athletes. We also found that the muscle injuries often affected the lower limb, especially the hamstring muscle groups. Similar findings were also noted in a study conducted among intercollegiate hockey players.[22] Furthermore, lower extremity muscle strain was the most frequent injury diagnosed at the 2007 International Association of Athletics Federations World Athletics Championships.[23] Excessive tensile force on muscle fibres during fast bursts of speed has been suggested to be the main cause of muscle injury. Such an injury predominantly affects muscles that span two joints, such as the biceps femoris, semimembranosus, semitendinosus, gastrocnemius and rectus femoris.[24]

The pattern of muscle injuries among Malaysian athletes is comparable to that reported in other studies.[22,23] However, the median DRP of 7.4 (IQR 8.5) weeks among the athletes in this study is longer than that in earlier studies.[6,25] A study conducted by Malliaropoulos et al in Greece reported a mean time loss from training and competition of 14.7 days among elite-level track-and-field athletes.[25] This shorter DRP could be explained by the higher proportion (64.5%) of low-grade muscle injury (grade 1) in Malliaropoulos et al's study.[25] Another study on hamstring injury among Australian footballers reported a

Table III. Predictors of duration to full return-to-play of more than six weeks after muscle injury.

Determinant	*B* (SE)	p-value	Adjusted OR	95% CI
Time to consultation > 1 wk	1.29 (0.32)	< 0.001	3.63	1.80–7.30
Recurrent injuries	0.76 (0.37)	0.038	2.14	1.04–4.38
Female gender	0.74 (0.37)	0.048	2.09	1.01–4.34

SE: standard error; OR: odds ratio; CI: confidence interval

median time of 26 days before the injured athletes returned to competition.[6] However, the authors of that study did not describe the severity of muscle injury suffered by the athletes.

The present study found that athletes who delayed medical consultation by more than one week (after the onset of injury) had a significantly higher likelihood of taking more than six weeks to recover compared to those who sought treatment earlier. In a study by Askling et al, a median DRP of 31 weeks was reported among 30 elite-level Swedish athletes who presented 12 weeks after sustaining hamstring injuries, with 47% of the athletes making the decision to retire after a follow-up period of 63 weeks.[26] Early management of muscle injuries was shown to affect the extent of injury and the amount of scar tissue formed, which influences the duration of muscle healing.[1,27,28] Early immobilisation (less than one week) has been shown to limit the size of connective tissue (scar) formed within the site of injury in rat gastrocnemius muscle.[27] In addition, early use of cryotherapy hastens regeneration and has been associated with significantly smaller haematomas, less inflammation and less tissue necrosis.[1,29] Educating athletes on the importance of early medical consultation following injury and improving medical accessibility (e.g. having readily available onsite medical team support) may help to shorten the duration between the time of injury and the first consultation, which may in turn positively affect DRP.

History of previous muscle injury is one of the most important risk factors for subsequent muscle injury. Athletes with a history of muscle strain are two to six times more likely to experience recurrent strains.[5,12] Some possible explanations for this observation include reduced tensile strength of scar tissue, decreased muscle strength, diminished muscle flexibility, as well as possible adaptive changes in the biomechanics and motor patterns of movements after injury.[22] Moreover, the current study found that athletes with a history of muscle injury were more likely to take more than six weeks to return to play than those with a new injury. A significantly longer recovery time was observed among National Football League athletes with hamstring re-injuries (56 days) compared to those with first-time hamstring injury (16.5 days).[30] In a laboratory study, the lack of activated myogenic satellite cells within the fibrotic discontinuity area (scar tissue) was suggested to be the phenomenon responsible for the delay in healing of recurrent muscle injuries.[31]

Female athletes with muscle injuries in the present study took a longer time (more than six weeks) to recover compared to male athletes. While the reason for this is unclear, it could be due to the difference in the circulating sex hormones between males and females. It has been found that there are significantly fewer inflammatory cells (neutrophils and granulocytes) infiltrating the vastus lateralis muscle of female university students after a standardised pain-inducing eccentric exercise compared to males.[32] Infiltration of the muscle with leucocytes and macrophages is important for satellite cell activation and initiation of muscle regeneration. Therefore, the oestrogen-attenuating effects on leucocyte infiltration may delay important stages in muscle recovery.[33-35] Bell et al demonstrated the presence of significant hamstring muscle extensibility changes throughout the different phases of the menstrual cycle,[36] which may increase the likelihood of sustaining acute hamstring injury, as was demonstrated in Watsford et al's study.[37]

Interestingly, the frequency of physiotherapy sessions did not affect the DRP in our study. Contrary to our findings, Malliaropoulos et al demonstrated that athletes diagnosed with hamstring injury who underwent a more intensive stretching programme had a statistically significant shorter time of recovery.[38] It should be noted that an optimal method for the treatment of muscle injury has yet to be identified.[39] Consequently, the treating physiotherapists in our study used different treatment protocols based on anecdotal reports and personal experience. The treatment protocols differed with respect to the type and sequence of activities prescribed, duration of the treatment session and the use of electrotherapeutic modalities, further complicating comparisons among the different regimens.

The high loss to follow-up rate of about 53% is of major concern, especially when it involves national-level athletes. It is, however, possible that the athletes who defaulted had recovered from their injuries, retired or sought treatment elsewhere. A prospective study to explore the factors associated with loss to follow-up is currently underway. It should also be noted that the reliability and accuracy of US in diagnosing acute back muscle strain is still not documented.[40] Hence, it is possible that other conditions such as abnormalities of the intervertebral discs and facet joints were missed or overlooked in these athletes. This study has demonstrated that the timing of first consultation, past history or recurrence of muscle injury, and female gender were useful factors in predicting the DRP among Malaysian athletes.

In conclusion, grade 2 lower limb muscle injury was the most common type of injury diagnosed among the national-level athletes in our study. The athletes with muscle injuries were conservatively treated, with a median DRP of 7.4 weeks. This study has identified several predictors of DRP of more than six weeks post muscle injury – time to first consultation of more than one week, recurrent muscle injury and female gender. These factors are important and should therefore be considered during early assessments of muscle injuries. Strategic steps need to be taken to ensure early consultation and treatment as soon as an injury occurs. It is important to increase awareness of the factors associated with extended DRP among athletes, coaches and practitioners involved in the care of athletes. A prospective study with a larger sample size could better show the associations between clinical assessments and outcomes, including potential variables with small to moderate effects. Such a study is being planned for the near future.

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