# The influence of a soccer season on non-contact injury and isokinetic peak torque of the quadriceps and hamstrings in professional youth soccer players

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# The Influence of a Soccer Season on Non- Contact Injury and Isokinetic Peak Torque of the Quadriceps and Hamstrings in Professional Youth Soccer Players.


## ABSTRACT

*Isokinetic strength screening is utilised within professional soccer. However, there has been little research on the interaction between seasonal changes in players' peak torque (PT) and injury incidence. Twenty-five (age 16.5±0.68 years) professional youth soccer players participated in the study. Bilateral isokinetic concentric (CON) and eccentric (ECC) testing of Quadriceps (Q) and Hamstrings (H) was conducted at three time-points across the season. Absolute CON and ECC PT were measured at 60 degree /sec and in a supine 170-degree position. Testing data was normalised to body mass. A mixed design (2 by 3) repeated measured ANOVA with injury as a co-variate was conducted to evaluate the effect of season and /or limb dominance on PT and injury incidence. With regard to the seasonal variation and injury incidence, an interaction was identified with respect to non-dominant limb (NDL) QCON (p=0.01) and to a lesser extent the dominant limb (DL) QCON (p=0.05). The seasonal variation of the PT of the NDL QCON was different between the injured and non-injured individuals. Non-injured individuals, QCON strength increased over the course of the season. While for the Injured players, QCON declined from pre-season to mid-season then increased but never recovered to starting pre-season values.*



Key Words: Injury; Soccer; Strength; Isokinetic; Non-dominant limb.


## INTRODUCTION

Maintaining the musculoskeletal performance and strength in elite youth soccer players while preventing injury over the course of the competitive season is a key goal and challenge in the

physical development of professional soccer players. The physical performance characteristics of match-play in soccer players has been identified as sprinting, jumping, landing, accelerations, decelerations and changes of direction (Taskin, 2008). In order to develop these soccer specific attributes appropriately, this often necessitates optimal planning and monitoring of applicable strength and conditioning seasonal based training over the competitive season. Hence, the importance for youth soccer Academies to consider each player's longer-term physical and mental welfare through injury risk and objective key strength assessments is fundamental **(Peek *et al,* 2018).**

Concentric and eccentric knee flexor and extensor strength development is fundamental for the optimisation of required physical performance characteristics over a full competitive season. Knee extensors are regarded, as prime movers for kicking, sprinting and jumping actions (Cerrah, 2011; Croisier, Ganteaume, Binet, Genty and Ferret, 2008) with the eccentric flexors, primarily involved in a protective action for the knee joint while also contributing significantly to knee stability (Bennell, Wajswelner, Lew, Schall-Riaucour, Leslie, Plant, and Cirone, 1998; Cometti, 2001; Croisier *et al* 2008). Accordingly, objectively monitoring any strength in soccer performance, may help sustain the explosive power required for performing intensive soccer actions and may minimise injury across the course of the season (Silva, Nassis and Rebelo, 2015).

Evaluating the strength of youth players objectively and accurately by practitioners utilising isokinetic testing has been recognised, as a valuable screening practise (Caruso, Brown and Tufano, 2012; Dirnberger, 2012). Exploration of the knee flexor and extensor strength variations over a competitive season with respect to the individual player's DL and NDL, are important. This helps to quantify the influence of likely training effects and the performance

63 demands on NCI incidence. These stresses may result in a disproportionate change in
64 isometric strength (**Peek *et al* 2018**) and isokinetic peak torque (Wrigley, 2000) on each limb
65 which could impact on both performance and injury incidence.
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67 There is also evidence to suggest, that the influence of training may not lead to sustained
68 increases in isokinetic peak torque across the full duration of the season. Indeed, a previous
69 study (Malliou, 2003) conducted on adult professional players identified, that stagnation and
70 decline of PT knee extensor strength occurs during different periods of the season. Such
71 seasonal changes may have an impact on physical strength development, functional
72 performance and on the capacity to avoid overuse non-contact musculoskeletal injury
73 throughout a season. These seasonal changes could have particular relevance for the elite
74 youth soccer player, who may be adjusting to the challenges of full-time training and having
75 to cope with the ongoing weekly demands of competitive match-play at a professional level
76 but also in relation to maximizing their physiological potential.
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78 To our knowledge, no study has considered the potential interaction between isokinetic
79 relative Q and H strength with NCI in professional youth soccer over a competitive season.
80 Consequently, the aim of the study was to investigate the interaction between NCI and
81 seasonal variations in isokinetic PT in the strength of the knee extensors and flexors. It was
82 hypothesised that there would be an interaction between seasonal variation in isokinetic PT
83 and NCI incidence in elite youth soccer players.
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## METHODS:

### Experimental Approach to the Problem

Isokinetic strength testing was performed on youth professional soccer players during the pre-season period (mid- July), then during January (mid-season) and finally during May (end of season) over a competitive soccer season for an English Premier League Category One Academy. The relative PT was calculated for all the players' (absolute PT / mass at time of tests) for both the DL and NDL. These relative PT data were analysed for seasonal changes. NCI was diagnosed by a Chartered physiotherapist at the club and the data was collated over the same time period of the season for all the participants. All the participants were deemed fit and healthy for testing. Only diagnosed NCI data resulting in the loss 4 days or greater from training/ matches were utilised for this investigation. The NCI utilised were mainly moderate 70% (greater than 7 days and less than 28 days) in nature. While mild NCI between 4-7 days were 18% and severe, (greater than 28 days) were 18% of the total NCI (Price *et al* 2004).

### Participants

Twenty-five professional, full-time, elite youth soccer players participated in this study. The physical characteristics of the players were as follows: age (16.5±0.68 years), stature (178.64±5.93cm), mass at pre-season (70.85±7.53cm), mass at mid-season (72.47±7.05cm), and mass at the end of the season (73.09±6.84cm). The players' ages were recorded and measurements of the players' mass in kg were logged at each of the testing periods. Stature was detailed in both upright and sitting positions, so that Peak Height Velocity for maturity

could be calculated (Mirwald, Baxter-Jones, Bailey, and Beunen, 2002). The study was conducted over a full English soccer season (mid-July to mid-May). Over the season, the players participated in normal day-to-day football practises for the entire season. (Table 1) Only the players (n=25) who attended all three isokinetic testing sessions participated in this study. The subjects gave their written informed consent to participate in the study, and written parental consent was obtained prior to participation. University Ethical approval was obtained for this study.

Procedures

Isokinetic PT of the knee extensors and flexors were measured during the time period outlined previously. Both concentric and eccentric evaluations of the Q and H muscle groups were obtained. These measurements were obtained on- site at a Premier League Category One Academy, under the supervision of a Chartered physiotherapist at the club, using a manufacturer maintained, Cybex NORM isokinetic dynamometer (CSMI, Stoughton, MA, USA). All tests were administered at the beginning of the day at the same time, prior to any activity.

To reduce the learning effect on the test results, a familiarisation period was administered prior to testing, this is particularly important for younger adults being tested eccentrically. Younger players may not be familiar with the complex neuromuscular demands of the muscle action required to produce a maximal effort.

Before testing, a general warm-up was conducted, consisting of 3 minutes cycling on a cycle ergometer at a moderate intensity followed by 20 seconds of both H and Q stretching. The stretching was active in nature. **For the PT test, the participants were tested over 5**

**maximum repetitions with 3 submaximal preparation repetitions prior to the actual data recording. There was a 2-minute rest period between each test implemented.** The most functional position with a hip – torso angle of 170 degrees (almost supine) for testing was utilised (Wiggin, 2006). Participants were instructed to keep their arms crossed across their chest during testing (Mujika and Padilla, 2000). **A sixty-degrees per second angular velocity was applied throughout all the tests.**

The NCI data utilised was diagnosed by the same Academy based Chartered physiotherapist. This aspect reduces the chances of inaccuracies and improves the consistency of the injury data (**Smpokos *et al* 2018).** The rehabilitation return to play process was overseen by an Academy based Chartered physiotherapist and the player was considered injured until the player was allowed full participation in training or match play as determined by an Academy Chartered physiotherapist. (Table 2 and Table 3)

The data was then subdivided by the research team into anatomical areas; upper limbs (Head, upper limbs and including Thoracic spine -*UL* ), pelvis region (including Lumbar spine and all anatomical structures, where their origin is connected to the pelvis area -*PR)* and the lower limbs, that included knee injuries and below - *KAB*).

Statistical Analyses

All outcome measures were tested for normality to determine whether parametric methods could be used for analyses. A One-way ANOVA with repeated measures was applied to test the effect of seasonal variations and limb dominance on the isokinetic peak torque of the knee

extensors and flexors. This was conducted for injured and non-injured participants independently. The effect of seasonal variation and injury status was also investigated using a one-way ANOVA with repeated measures; once for the dominant limb and once for non-dominant limb. An alpha level of 0.05 was selected and all analyses was performed using SPSS version 25 (NY, USA)

## RESULTS

Pre/ Mid and end of season elite youth players mean relative results for an English Premier League category one academy are displayed in table 4.

*Effect of Seasonal variations and Limb Dominance on Injured and Non-Injured Participants (Analysed Independently).*

Among the 25 participants, 17 individuals had some form of NCI during the season. An ANOVA with repeated measures was applied to test the combined effect of seasonal variations and limb dominance on the Isokinetic peak torque of the knee extensors and flexors once for injured (n=17) and once for non-injured (n=8) participants. In both non-injured and injured participants, the result was similar to the analysis previously conducted for pooled data. There was a significant effect of seasonal variation in quadriceps concentric (P=0.001 and p= 0.037) and eccentric (P=0.006 and p=0.029) isokinetic peak torque, irrespective of leg dominance. The decrement pattern in the first part of the season followed by a recovery in the second part of the season was also similar to the previous test with pooled data.

*Effect of seasonal variation and injury status with respect to Limb Dominance*

A one-way repeated measures ANOVA was applied to test the combined effects of seasonal variations and injury incidence. The test was conducted on the dominant and non-dominant leg separately.

*Effect of seasonal variations and injury status on Dominant Limb*

The effect of seasonal variations when injury incidence was added to the ANOVA model was significant for *HECC measurements (p=0.022).* A Tukey post-hoc pairwise comparison demonstrated that the significant effect related to the increase from mid-season to the end of season measurement (p=0.017).

The effect of injury incidence was significant for QCON (p=0.012), HECC (p=0.047) and QECC (p=0.05) with the *dominant limb of the non-injured players* generating significantly greater isokinetic peak torque values than injured participants throughout all three time points (Figure 1). The isokinetic peak torque values were not significantly different for HCON (p=0.526) across the course of the season between the injured and non-injured players. *There was an interaction (p=0.05) between seasonal effect and injury status in QCON*, which indicated that the influence of seasonal variations in QCON isokinetic peak torque on the dominant limb of injured individuals was different from its influence on non-injured individuals (Figure 1). For both non-injured and injured individuals, QCON isokinetic peak torque values of the dominant limb decreased from pre-season to mid-season but at different rates (Figure 1). For the non-injured group, the values recovered and reached a higher value than that in pre-season (Figure 1). While, the injured individuals never recovered from the drop recorded at mid-season (Figure 1).

*Effect of seasonal variations and injury status on Non-Dominant Limb*

*The only scenario where seasonal variations and injury incidence generated an interaction was with respect to QCON (p=0.004) (Figure 2) and QECC (p=0.017),* which indicated that the influence of seasonal variations in isokinetic peak torque on the non-dominant limb of injured individuals was different from its influence on non-injured individuals (Figure 2). *For non*-injured individuals, both QCON (Figure 2) and QECC isokinetic peak torque values of the non-dominant limb increased over the course of the season. While for the injured group, the values declined by mid-season and then increased up to the end of season, but never recovered to pre-season recorded values (Figure 2). There was no interaction between seasonal variations and injury incidence for the other three isokinetic peak torque (QECC; HCON; HECC) variables. Irrespective of the time point measurements during the season, non-injured participants generated significantly higher QECC isokinetic peak torque values than injured participants (p=0.011). This was not, however, the case for QCON, HCON and HECC (Figure 2) measurements, demonstrating that these isokinetic peak torque values were not significantly different between injured and non-injured players on their non-dominant limbs.

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252 DISCUSSION

253 Several notable findings resulted from the current study. PT for players who were vulnerable
254 to NCI over the season tended to demonstrate a significant decline in both their bilateral
255 limbs extensor knee concentric strength. However, this QCON PT strength decline was
256 greater with respect to their NDL (Figure 1). This PT decline demonstrated a trend to rebound
257 from the mid-season testing period onwards, but never fully recovered to the initial PT pre-
258 season values (Figure 1). Conversely, the non- injured players' bilateral QCON PT improved
259 over the competitive soccer season (Figure 1). Both the injured and non-injured players'
260 HECC PT over the competitive season demonstrated no significant interaction. The results
261 demonstrated a significant interaction for both the QCON DL, but a greater interaction for
262 QCON NDL PT for the players who sustained NCI over the competitive season (Figure 1).

There were no significant interaction between player's bilateral HECC PT values recorded over the season. The injured player's QCON PT values decreased over the season in this study and this pattern was also observed in previous elite youth player studies (Forbes, 2009; Lehnert, 2014).

The majority of the non-contact muscle injuries with varying seasonal severity (Table 3) in this study stemmed from the connected pelvic anatomical region (Table 2 and Table 3) - identified and categorised by their anatomical area of origin -including; osteitis pubis, hamstring, hip flexors, quadriceps, adductors, gluteus and piriformis. The present findings identifying this region for injury is similar to other reported injury-based youth soccer studies (Price, Hawkins, Hulse and Hodson, 2004) and adult soccer studies (Ekstrand, 2008; Ekstrand, Hägglund and Waldén, 2011; Mallo, González and Veiga, 2011). A recent study (Bond *et al,* 2017) concluded, that compensation for muscle power unevenness may occur during functional tasks. Thus, speculation towards the decline in strength identified in the player's NDL quadriceps may lead to muscle and asymmetrical imbalances developing around this key pelvis area. Conversely, NCI may lead to the deterioration in strength. Thus, consideration could be directed towards the possibility, that NCI may precede the decline in the injured players' unilateral NDL Q strength. This weakening in Q strength dominance towards a unilateral limb was also identified within Academy youth soccer players' isometric strength **(Peek *et al,* 2018).** In conjunction, this asymmetrical greater reduced strength of the NDL QCON PT among the injured players contrasts to the eight non-injured players who continued to gain and maintain their bilateral PT QCON over the season (Figure 1)

The vulnerable calendar periods for NCI developing among the elite youth players seems to be between the months of November to March (Table 2 and Table 3). During the pre-season to mid-season period, the NCI were 39.2 injuries per 1000 hours of training and match

activity. During the period of mid-season to the end of season, the NCI demonstrated 61.3 injuries per 1000 hours of training and match activity. However, the NCI periods identified between the months of November to March (Table 2 and Table 3) were concomitant with the lowest ND PT QCON recorded values of the injured players (Figure 1).

It appears that there is an inverse interaction between knee extensors PT NDL decrements across the first half of the season and the increased incidence of NCI. The periodical seasonal injury periods observed in this youth study are comparable to both an adult (Read, Jimenez, Oliver and Lloyd, 2018) and NCI youth soccer injury-based results (Sangnier, 2007). These studies typically highlight injuries peaking around the January mid-season period and at the starting periods of pre-season. It is acknowledged, that the aetiology of these NCI may not just stem from the decrement in NDL QCON PT, but this could be a factor responsible for the focused November to March period exhibiting a peaked response towards player's NCI rates.

This may be rationalised by the effects of adjustment to full-time soccer training for elite youth players (Lehnert, 2014; Sangnier, 2007) with the interactions of NCI affecting strength and/or strength decreases effecting NCI phases. However, other internal and external NCI influences, such as previous injury history may be a factor in affecting youth players' injuries (McCall, Carling and Davison, 2015) in conjunction with the decreases in QCON NDL strength in the season.

Due to small variabilities in player's body mass over the course of the season, all PT values were normalised for body mass at the time of testing. The absolute values from the present study were in line with previous research (Iga *et al*, 2009; Lehnert, 2014). The decrement in the first half of the season for QCON PT and the blunted PT recovery pattern noted in the second half of the season may be the result of the first exposure to full time training adjustments in these elite youth soccer players (Lehnert, 2014). There is currently limited

research on seasonal PT variations in elite youth soccer players. The limited research that does exist has reported (Price *et al*, 2004) that a decrease in concentric extensors absolute strength was noted during the season in elite youth (U-17) soccer players.

This mid-season testing strength decrease, with the NDL knee extensors tested at 60 degree/sec was also noted in a study (Eniseler, 2012) involving professional adult soccer players. These authors demonstrated that the extensors PT decreased from the initial screening period in July to December. These findings suggest that this decrement in NDL PT may be a product of seasonal mal adaption rather than a product of age.

A recent study (Rhodes, McNaughton and Greig, 2019) involving adult professional soccer players, focusing solely on the player's dominant limb eccentric hamstring muscles and implemented over a much shorter testing period (72 hours rather than a season) demonstrated players' strength decreasing due to 90 minutes stimulated exercise with a projected return towards baseline PT values, estimated to be around 96 hours for 60 degrees/sec isokinetic PT strength recovery. Though, the influences of a competitive season, injury and the characteristics for professional youth players may affect the potential time recovery towards strength in soccer.

This PT diminution may suppress the initial adaptation process for younger professional players, which may occur within the quadriceps' NDL muscle group. Yet, this is principally relevant towards the less utilised and less sport specific conditioned NDL prime mover muscle group. While the DL is more often associated in kicking, jumping and with the ground reaction forces associated with overcoming sprinting inertia (Psotta, 2011). The loss of adaptation for the NDL is an issue, which may negate performance and increase the risk of potential injury with any concomitant functional asymmetry (Price *et al*, 2004; **Peek *et al,***

**2018)**. Thus, an important aspect of the training process within annual cycles is to evolve and /or maintain muscle strength (Lehnert, 2014). It may be postulated, that any functional asymmetry with the NDL would be targeted as a training development focus for the elite youth soccer player (Sannicandro, Piccinno, Rosa and De Pascalis, 2011; **Peek *et al,* 2018).** Hence, it is possible to speculate, that elite youth players may be less seasonally attuned than professional adult soccer players to full-time training exposure, potential fatigue elements and competitive match exposure (Sangnier, 2007).

This was a pilot investigation that has generated some interesting trends which warrant further investigation in a larger cohort of elite U-18 Premier League Category One soccer players. The unique intensity and volume of matches played at U-18 level in the English Premier League make our pilot investigation valuable in demonstrating interactions between PT and injury incidence that warrant further investigation.

The main limitation of this study is, that it reflects the strength and conditioning and on-pitch training philosophy of one club. Future studies should incorporate multiple clubs within the analyses to see whether the pattern of a greater NDL PT decline and increase in NCI are directly linked.

Another potential limitation of this study is that the RPE and seasonal training load data presented (Table 1) is not the same U18 squad that was used in the study presented, but as a result of the Elite Player Performance Plan curriculum for all Premier League Academies it is exactly the same training schedule that the participants in our study would have used.

In conclusion, the reduction of isokinetic peak torque values for quadriceps concentric peak torque, particularly towards players non- dominant limb tested isokinetically at 60

degrees/sec across the course of a season may have an influence on the predisposition of NCI associated with elite youth soccer players within an academy environment. This potential affiliation of diminished strength over the competitive season and an increased vulnerability to overuse NCI developing may require attention for all professional soccer staff and players.

## PRACTICAL APPLICATIONS:

Systematic strength screening with a strategic emphasis on conditioning players' NDL for full seasonal development may be required in soccer.

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