Non-Contact Anterior Cruciate Ligament Injuries in Association Football: A study of Modifiable Neuromuscular Risk Factors among Top Tier Players in Malta

Matthew Muscat-Inglott*, Clayton Camilleri
Corresponding Author: matthew.muscat.inglott@mcast.edu.mt
*Institute of Community Services, MCAST

Abstract: Given the general prevalence and consequences of anterior cruciate ligament injuries in international football, a non-experimental quantitative observational study was designed to explore locally contextualised risk factors and injury outcomes among top tier male players in Malta. The repeated tuck jump assessment was selected as a convenient, unobtrusive and field-based primary data collection instrument for non-clinical assessment of neuromuscular and other risk factors, among a sample of 27 local premier league players. A final tally of 44.44% of the participants eventually exceeded a predetermined field test cut-off score, indicating the need for definitive preventive measures locally. There were no significant differences in scores between players of different teams, playing positions, preferred shoe brand, or dominant foot, further indicating a generally systemic nature to local risk factor exposure. The most frequently observed neuromuscular deficits were, specifically, trunk dominance and leg dominance, providing a clear indication of how future interventions or programmes in Malta might actually be structured and prioritised.

Keywords: Anterior cruciate ligament, neuromuscular, injury risk factors, football, soccer.

Introduction

While most non-contact injuries in association football tend to occur in the lower extremities (Wallace et al. 2008; Read et al. 2016), anterior cruciate ligament (ACL) injuries specifically account for a majority of knee ligament injuries evaluated by sports medicine practitioners (Acevedo et al. 2014). Several additional adverse effects of ACL injuries have been identified including long-term disability, chronic knee instability, meniscus tears, cartilage injury, development of osteoarthritis as well as financial burden on those afflicted and others (Acevedo et al. 2014; Hewett et al. 2010). In the case of females, a majority will exhibit symptoms of osteoarthritis and associated pain in a higher proportion to their male counterparts, in addition to experiencing symptoms and pain within shorter elapsed time periods since the original injury event (Sugimoto et al. 2015). At least half of all athletes will not return to their sport within a year of surgical ACL reconstruction, a quarter will change sports, and roughly 10% will cease sports participation altogether (Acevedo et al. 2014).

In tandem with the growing worldwide popularity of football, ACL injuries are reportedly on the rise (Hewett et al. 2010). In lieu of any local primary data suggesting otherwise, anecdotal reports among pertinent stakeholders meanwhile raise little cause for restraint in extending this assumption to the Maltese context. According to a 2018 survey by the national governing body, football was the most practised sport in Malta among children...
and youths, and third among adults. Followed by lack of time, injury was cited as the second most common reason Maltese adults stop playing the game (Malta Football Association 2019). Thus, given the general prevalence and consequences of ACL injuries, the present study was designed primarily to identify prospective risk factor trends in top tier players in Malta, with a view to informing, in a broader sense, systemic ACL injury prevention initiatives in the local football scene.

Literature Review

The ACL is a key stabiliser of the knee, a joint itself traditionally considered to be among the most unstable in the body (Arnoczky 1983). The ACL is a collagenous structure with femoral and tibial attachments serving to constrain forward (anterior) and internal motion of the tibia. Some structural anatomical variance has been observed across individuals (Acevedo et al. 2014; Kopf et al. 2008), rendering genetics at least one of several key risk factors for injury. A dedicated body of international biomechanical and epidemiologic research has set about investigating mechanisms and risk factors associated with ACL injury outcomes, primarily with a view to developing more effective screening and intervention strategies (Acevedo et al. 2014; Alentorn-Geli 2009). Some notable studies by undergraduate and graduate students in Malta have explored radiographic diagnosis of ACL injuries (Zarb and Debono 2007) and recovery from reconstruction surgery (Ryan 2018), from the clinical perspective. To date, we are unaware of any studies on the interaction between locally contextualised risk factors and ACL injury outcomes among football players in Malta from a sports epidemiologic perspective.

In terms of ACL injury mechanisms, football is classified as a high-risk sport largely due to the high frequency of jumping (and landing), cutting (and feinting), and sudden deceleration movements that characterise it. During such actions, where the body centre of mass (COM) is shifted outside the base of support in conjunction with loading of the knee in a valgus (buckled inward) position, the structural integrity of the ACL is exposed to increased risk of compromise (Acevedo et al. 2014; Alentorn-Geli 2009; Hewett et al. 2010; Read et al. 2016). Female athletes are known to be at higher risk of ACL injury in part due to an increased tendency towards knee valgus (Wallace et al. 2008). Brophy et al. (2014) reported that a majority of ACL injuries occur during forward movement of the body, while engaged in defensive actions.

Risk factors associated with the injury are typically categorised as extrinsic and intrinsic, with varying degrees of modifiability. Extrinsic risk factors include weather, physical game-related perturbations, level of competition and shoe-surface interactions. For mitigating the risk of excessive traction between shoe type and ground surface (Mansfield and Bucinell 2017), natural grass is considered preferable to artificial turf, combined with dedicated turf or round-studded shoes to promote lower knee torque values (Villwock et al. 2009). Given that local football players will not typically train and compete exclusively on natural grass, shoe-surface interactions represent at least one locally nuanced extrinsic and partially modifiable risk factor in need of further investigation. Studies on injury outcomes according to playing position as an additional possible external risk factor have been inconclusive so far in terms of outcome prevalence (Della Villa et al. 2018), although actual causal mechanisms are thought to differ somewhat between defenders and strikers (Serpell et al. 2012).

Since intrinsic risk factors like genetics, age and gender are largely non-modifiable, research has instead increasingly focussed on modifiable intrinsic factors like Body Mass
Index (BMI), cardiorespiratory endurance (for delaying the onset of fatigue and resulting deterioration of movement technique) and, most notably, neuromuscular deficits. The latter have been referred to as among the most important modifiable ACL injury risk factors (Myer et al. 2008), and are typically further categorised as either ligament, leg, quadriceps or trunk dominance. In ligament dominance, the positioning of the leg causes excessive direct loading on the ACL. In leg dominance, a given leg is prioritised and disproportionately loaded in comparison to the other. In quadriceps dominance, the quadriceps are prioritised over the hamstrings and posterior chain muscle groups, resulting in forward shifting of the athlete’s COM. Trunk dominance is characterised by a general lack of control over the positioning of the trunk, resulting in excessive sway and COM shifts (Acevedo et al. 2014; Hewett et al. 2010).

A range of laboratory- and field-based assessments of various movement tasks including hopping, single leg countermovement jumps, and two-legged tuck jumps have been designed to non-clinically assess for neuromuscular risk factors in athletes (Read et al. 2018). Measurement of knee valgus during depth jump and tuck jump landings performed in laboratory settings have demonstrated good reliability in this respect (Padua et al. 2011; Redler et al. 2015). The dynamic repeated tuck jump assessment (TJA) as presented in Myer et al. (2008), meanwhile, has also been used as a field-based test in several studies on ACL injury prevention, showing good inter- and intra-rater reliability without the need for specialised equipment (Fort-Vanmeerhaeghe et al. 2017; Hewett et al. 2010; Klugman et al. 2011; Read et al. 2016).

The TJA is based on identifying ten predefined technical flaws in subjects’ performance of a bout of maximal repeated tuck jumps within 10 seconds (Hewett et al. 2010; Myer et al. 2008; Myer et al. 2013). Cumulatively, the predefined flaws test for the four main neuromuscular deficits. The TJA is credited with strong ecological validity for football, given that players must continuously react to changing game situations and movement perturbations (Hewett et al. 2010). While actual predictive validity is as yet to be ascertained in long-term cohort studies that test for association between field-based screening test scores and the subsequent incidence of ACL injuries (Fox et al. 2015), Hoog et al. (2016) found that athletes in high-risk sports (football, basketball and volleyball) obtained relatively high TJA scores in comparison with traditionally lower risk sports.

Research Questions

To explore contextualised interactions between risk factors and ACL injury outcomes in Malta, we selected the TJA as a convenient, unobtrusive, field-based instrument that would enable us to access and non-clinically assess a representative sample of local top tier male players for neuromuscular as well as several additional factors discussed in the literature. Therefore, our main research questions were:

**Question 1**
How do Maltese premier league players fare overall in the TJA?
Since studies based on TJA data will typically reveal trends towards specific predefined flaws (Hoog et al. 2016).

**Question 2**
What unique trends exist, if any, among local premier league players in terms of specific neuromuscular risk factor exposures?
**Question 3**
What additional significant interactions can the data reveal about ACL injury risk according to TJA scores across additional factors such as team, playing position, shoe brand, dominant foot and age?

**Method**

Following clearance from the college research ethics review board, seven teams from the Maltese men’s BOV Premier League were contacted, of which six eventually agreed to participate in the study. Groups of five male players without previous history of ACL injury were randomly selected by the coach of each team, with the exception of two teams from which smaller groups of three and four were recruited. A goalkeeper, defenders (n=9), midfielders (n=10), wingers (n=4) and strikers (n=3), aged between 18 to 35 (Mean=24.7, SD=4.4) comprised the final total sample (N=27). They were predominantly right-footed (85%, n=23), and wore three different brands of footwear (n=9, 14, 4).

Data collection was carried out for each group of participants across six non-consecutive days of testing throughout the month of April 2019, in their respective team training grounds with all normal health and safety procedures in place. Club representatives and players were reminded about their rights to confidentiality and option to withdraw from the study at any time. Performance of the TJA was scheduled for the start of the main training session immediately following the standard team warm-up to minimise risk of injury from either insufficient preparation or excess fatigue. The participants were first asked to provide their age, choice of shoe brand and dominant foot, and to confirm they had no prior history of ACL injury. The TJA was then explained and demonstrated. The performances were filmed from the frontal view, with participants’ prior consent, and later analysed using Kinovea (Version 0.8.27) open source video analysis software to ensure a more rigorous evaluation and identification of flaws than would have otherwise been possible using real-time visual observation alone. The 10 predefined flaws comprising the TJA scoring system are shown (below) in Table 1.

<table>
<thead>
<tr>
<th>Flaw</th>
<th>Descriptor (Myer et al. 2008: 8)</th>
<th>Neuromuscular Deficit (Myer et al. 2013)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>“Lower extremity valgus at landing”</td>
<td>Ligament dominance</td>
</tr>
<tr>
<td>2</td>
<td>“Thighs do not reach parallel (peak of jump)”</td>
<td>Trunk dominance</td>
</tr>
<tr>
<td>3</td>
<td>“Thighs not equal side-to-side (during flight)”</td>
<td>Leg dominance</td>
</tr>
<tr>
<td>4</td>
<td>“Foot placement not shoulder width apart”</td>
<td>Ligament dominance</td>
</tr>
<tr>
<td>5</td>
<td>“Foot placement not parallel (front to back)”</td>
<td>Leg dominance</td>
</tr>
<tr>
<td>6</td>
<td>“Foot contact timing not equal”</td>
<td>Leg dominance</td>
</tr>
<tr>
<td>7</td>
<td>“Excessive landing contact noise”</td>
<td>Quadriceps dominance</td>
</tr>
<tr>
<td>8</td>
<td>“Pause between jumps”</td>
<td>Trunk dominance</td>
</tr>
</tbody>
</table>
Scores were allocated to each participant according to how many flaws were identified throughout their filmed 10-second bout of repeated tuck jumps. Team coaches were informed of the test results of their participating players following completion of this stage of the analysis. The data were finally imported into R Studio (Version 1.1.414), an open source software for statistical analysis. Descriptive statistical tools were used first to test for normality, and to describe and present the data. A range of inferential statistical tests were then run to test various hypotheses underlying the main research questions, including one-way ANOVA; independent samples T Test; Chi Square; likelihood ratio Chi Square; and Pearson r. A Confidence Interval of 95% and Alpha level of 5% (α=.05) were used for interpreting statistical significance.

Results and discussion

Question 1

To address the main research question regarding overall performance on the TJA, basic descriptive statistics were run on the overall scores. The final mean score was 5.19 (SE=.29, SD=1.49, CI=4.59-5.78). Despite a slight negative skew of -.39 (SE=.44), the score data were considered approximately normally distributed, as shown (below) in Figure 1. The Shapiro-Wilk test was used to confirm the assumption of normality for further parametric testing (W=.95, p=.16).

Figure 1: Histogram with normal curve overlay showing approximately normal distribution of TJA scores (Skewness=-.39, Kurtosis=-.42)
According to Myer et al. (2008), overall TJA scores of six or more observed flaws indicate the athlete should be targeted for further technique training. A low standard deviation of 1.49, and interquartile range of 2 (given a median of 5) meanwhile indicate a somewhat alarming proximity of the majority of participants around the TJA cut-off value, supporting Hoog et al. (2016) as they assert that football can indeed be considered a high-risk sport, according to TJA scores. Table 2 below shows the main score frequencies with the main cut-off point marked for scores of 6 and over.

<table>
<thead>
<tr>
<th>TJA Score</th>
<th>Frequency</th>
<th>Percent (%)</th>
<th>Cumulative Percent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2</td>
<td>7.41</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>3.7</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>18.52</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>25.93</td>
<td>55.56</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>25.93</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>4</td>
<td>14.81</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>3.7</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Frequency distribution of scores with TJA cut-off indicator

A median value of 5 suggests that the ‘average' participant in a normally distributed sample of premier league football players in Malta, is one flaw away from the TJA cut-off. As indicated in Table 2, 55.56% (n=15) of the observations fell below the cut-off, while the remaining 44.44% (n=12) were above it and thereby in need of some form of specialised neuromuscular training. This finding alone would appear to suggest any significant reduction in the prevalence of ACL injuries in Maltese football would require relatively substantial and widespread preventive measures, targeting a majority of premier league players whose TJA scores can be assumed to also be tightly clustered around the cut-off score. Similarly large-scale injury prevention initiatives have been disseminated elsewhere via workshops and coach education programmes with some success, providing models of good practice. Successful initiatives have been characterised by their emphasis on promotion rather than imposition of evidence-based recommendations (Bizzini et al. 2013).

Question 2

To address the second research question, an analysis was carried out on the observations made according to the 10 predefined TJA flaws themselves. Figure 2 (below) shows the frequency distribution arranged from the least to most frequently exhibited flaws.
A Chi Square test of homogeneity showed that the observed proportions were sufficient to reject the null hypothesis of expected equal distribution across all flaws ($\chi^2=104.42$, df=8, p<0.001). In other words, the evidence supports the notion that a specific (and statistically significant) trend is indeed at play in the local context. If local premier league players are to undergo any form of ACL injury prevention programme, the trend gives us a clear indication of how such a programme might actually be structured and prioritised.

Constituting this trend, the five most frequently occurring flaws associated with the main neuromuscular deficits were; inconsistent landing footprints (100%, n=27) and failure to reach parallel thigh height in flight (74%, n=20), representing *trunk dominance*, as well as asymmetry between the legs both on landing (85%, n=23) and in flight (67%, n=18), representing *leg dominance*. So, the findings indicate the most prevalent modifiable intrinsic risk factor exposures among local premier league football players are, specifically, trunk dominance characterised by a lack of proprioception and stability in the trunk (Hewett and Myer 2011), and leg dominance characterised by disproportionately greater strength, coordination and balance in the dominant leg (Hewett et al. 2005).

While the second most frequently observed flaw (Flaw 9 – technique deterioration within 10 seconds) is not directly associated with one of the four main neuromuscular deficits (Myer et al. 2013), it has been separately described as an indicator of *neuromuscular fatigue* (Fort-Vanmeirhaeghe et al. 2017: 118). Meyer et al. (2008) simply present Flaw 9 as a matter of technique proficiency. In any case, Flaw 9 seems to imply a general lack of exposure to specific power-based or plyometric-based activity, adding further credence to the recommendation that local teams include more of this type of training in their programmes.

Multi-component ACL injury prevention programmes spanning pre-season and in-season maintenance phases are recommended, where the maintenance phase may consist simply of activities incorporated into the normal team warm-up. Set warm-ups like the FIFA 11+ programme have been designed for just such a purpose, and have been shown to reduce
injury incidence in amateur football players (Bizzini et al. 2013). Programmes should include a combination of neuromuscular training, strength training, aerobic conditioning, plyometrics, proprioception/balance training, landing technique practice and stretching, and are recommended over single-component programmes based on any one method in isolation (Acevedo et al. 2014; Alentorn-Geli, 2009; Sugimoto et al. 2015; Wallace et al. 2008). The evidence suggests, therefore, that prevention programmes applicable in the local context should include said components, with an additional special focus on what Hewett et al. (2010) recommend for trunk strengthening and landing technique refinement, to address the specific neuromuscular deficits identified in this study.

In a local undergraduate dissertation, Degiorgio (2011) showed that local premier league coaches generally understand the importance of physical conditioning, and have largely embraced the practice of working with specialised physical trainers/strength and conditioning coaches. In this sense, systemic initiatives aimed at reducing ACL injuries among top tier local football players might include the provision of adequate support for all coaching staff responsible for the physical conditioning of their players, in safely and effectively implementing complete multi-component programmes that prioritise trunk strength/stability, leg balance/symmetry and safe landing technique.

**Question 3**

To address the third research question concerning additional interactions in data, the normally distributed overall score values were treated as the dependent variable in a series of one-way ANOVA tests by team, playing position, and shoe type as the independent variables. Levene’s test was used to verify the assumption of homogeneity of variances in the ANOVA tests, and was duly satisfied in each instance (p>.05). An independent samples T Test was run to test differences by dominant foot, and Pearson r to test for association with age.

The tests revealed no significant differences in TJA scores between players of different teams (F=3.81, p=.06), playing positions (F=1.52, p=.23) shoe brands (F=3.33, p=.08), or dominant foot (t=.61, p=.56). A visual representation of the variance of scores by team is given in Figure 3 (below). The lack of statistically significant differences across teams and all other factors appears to further intimate the systemic nature of overall risk exposure trends among premier league players in Malta, with individual club practices and environments not accounting for any significant effect on overall ACL injury risk according to TJA scores.
Figure 3: Visual representation using box plots and overlay of the overall mean score of 5.19 (SD=1.49) and confidence interval (CI=4.59-5.78). The box locations in relation to the mean, confidence interval, and each other, indicate that while there was some difference across teams, this was not statistically significant.

A further series of Chi Square tests of independence were carried out to explore the same interactions for each individual TJA flaw. Flaws 7, 8 and 10 were omitted at this stage, given that distributions were exactly equal across each of the independent variables. Table 3 (below) reports the resulting $\chi^2$ statistics and significance levels for the seven remaining flaws each by team, position, shoe brand and dominant foot.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team</td>
<td>6.94 (.23)*</td>
<td>3.62 (.60)*</td>
<td>4.82 (.44)*</td>
<td>12.88 (.03)*</td>
<td>6.42 (.27)*</td>
<td>10.38 (.07)*</td>
<td>8.27 (.14)*</td>
</tr>
<tr>
<td>Position</td>
<td>7.62 (.12)</td>
<td>4.06 (.40)</td>
<td>4.25 (.37)</td>
<td>5.48 (.24)</td>
<td>2.00 (.74)</td>
<td>9.39 (.05)</td>
<td>1.34 (.86)</td>
</tr>
<tr>
<td>Shoe brand</td>
<td>0.49 (.78)</td>
<td>2.16 (.33)</td>
<td>5.16 (.07)</td>
<td>5.22 (.07)</td>
<td>2.38 (.30)</td>
<td>1.37 (.50)</td>
<td>0.43 (.81)</td>
</tr>
<tr>
<td>Dominant foot</td>
<td>6.83 (&lt;.01)</td>
<td>1.64 (.20)</td>
<td>0.15 (.70)</td>
<td>1.36 (.24)</td>
<td>4.61 (.03)</td>
<td>0.39 (.53)</td>
<td>0.39 (.53)</td>
</tr>
</tbody>
</table>

Table 3: Chi Square test results and associated p values for individual criteria by the factors team, position, shoe brand and dominant foot

* Where the assumptions for Chi Square were not met in terms of minimum expected frequencies (<5), the Likelihood Ratio Chi Square significance levels are reported instead

Three significant interactions emerged from the additional Chi Square tests, two of which concerned left-footed players. Firstly, all of the left footed players (n=4) in the study exhibited knee valgus (Flaw 1); and secondly, they demonstrated fore and aft misalignment of landing stance (Flaw 5) which was evenly distributed among left-footed players, but underrepresented among right-footed players. While a majority of ACL injuries in male football players tend to occur in their dominant leg (Brophy et al. 2014), the possibility that prevalence may differ among left-footed players, specifically,
is intriguing. Nonetheless, given that both these flaws are only partially representative of different neuromuscular deficits, and therefore paired with additional flaws that were not significantly different according to dominant foot, these particular findings are not conclusive.

The third significant additional interaction to emerge revealed that half of the teams showed a disproportionately high ratio of players exhibiting Flaw 4 (landing stance not shoulder width), while for the remaining teams, the ratios were disproportionately low. Once again, the lack of any covariance among Flaws 1 and 4 as combined measures of ligament dominance render the finding inconclusive from a neuromuscular deficit perspective. There is little evidence to support the assumption that unique factors at play within different premier league teams significantly affect ACL injury risk according to TJA scores.

And finally, in terms of age, while ACL injury risk is known to peak for males in their mid to late twenties, there is little evidence to date to support the assumption of any additional linear association between incidence of the injury and age (Serpell et al. 2012). Indeed, no association whatsoever between the TJA scores and age was found in this study (r<0.01, p=.99).

Conclusion

Limitations and future research

Several limitations became apparent throughout the course of planning and implementing this study. The TJA was designed for use in environments where one can assess, in reference to Flaw 7, the noise generated by each participant upon landing as a measure of quadriceps dominance. Given that the testing was conducted outdoors in participants' regular training grounds, this flaw was difficult to observe. Indeed, the flaw was not observed/recorded in any of the participants. Given that this is the only flaw pegged to quadriceps dominance (Myer et al. 2013), one of the four main neuromuscular risk factors was not effectively assessed in this study. It is worth noting, however, that this limitation indirectly reinforced the main premise of our response to the first research question, inasmuch as effective measurement of Flaw 7 could only have increased the final TJA scores, adding yet further urgency to the claim that systemic initiatives are needed to address ACL injury risk among male premier league players in Malta.

In terms of generalisability, this study was focussed on top tier players. So, while the findings indicate a relatively high proportion of ACL injury risk exposures among premier league players, this claim cannot by generalised to other levels of Maltese football. Our decision to focus on the highest competitive level nationally was motivated by a prevailing aspiration towards catalytic authenticity. In other words, our findings are based in and around top tier local football, and are therefore partially addressed at relevant stakeholders in ascendancy, with both the capacity and incentive to affect systemic change.

In future studies, we plan to explore the replicability of these findings across other levels of competitive as well as non-competitive recreational football in Malta. Additional prospective research aims include a case-control approach to investigating the effects of different playing surfaces used by local players on ACL injury prevalence, as well as a longitudinal cohort study approach to assessing the general predictive validity of the TJA in local players.
In conclusion, we found that the ‘average’ premier league player in Malta is at least one flaw away from the TJA cut-off score, engendering recommendation for specialised neuromuscular training to reduce ACL risk factor exposure. The final tally of 44.44% of participants actually exceeding the cut-off is indicative of a need for definitive preventive measures within top tier local football. There were no significant differences in TJA scores between players of different teams, playing positions, preferred shoe brand, or dominant foot, further indicating a generally systemic nature to risk factor exposure in local top tier football.

The most frequently observed neuromuscular deficits were, specifically, trunk dominance and leg dominance, as evidenced by high frequencies of inconsistent landing footprints, failure to reach parallel thigh height in flight, as well as asymmetry between the legs both on landing and in flight according to the TJA. In the event of prospective systemic ACL injury prevention initiatives and/or programmes, these trends provide a clear indication of how such interventions might actually be structured and prioritised.

Coaching staff responsible for the physical conditioning of players are ultimately advised, given current recommendations and the specific findings of this study, to implement multi-component programmes spanning pre-season and in-season maintenance phases that combine neuromuscular training, strength training, aerobic conditioning, plyometrics, proprioception/balance training, technique practice and stretching, while prioritising trunk strength/stability, leg balance/symmetry and safe landing technique.

References


Degiorgio, C. 2011. An Investigation on the Use of Strength Training in Soccer Players in
Relation to their Performance, Higher Diploma Thesis. University of Malta (Malta).


Myer, G. D., Stroube, B. W., DiCesare, C. A., Brent, J. L., Ford, K. R., Heidt, R. S., and Hewett,


