What do community football players think about different exercise-training programmes? Implications for the delivery of lower limb injury prevention programmes

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ABSTRACT

Background Players are the targeted end-users and beneficiaries of exercise-training programmes implemented during coach-led training sessions, and the success of programmes depends upon their active participation. Two variants of an exercise-training programme were incorporated into the regular training schedules of 40 community Australian Football teams, over two seasons. One variant replicated common training practices, while the second was an evidence-based programme to alter biomechanical and neuromuscular factors related to risk of knee injuries. This paper describes the structure of the implemented programmes and compares players’ end-of-season views about the programme variants.

Methods This study was nested within a larger group-clustered randomised controlled trial of the effectiveness of two exercise-training programmes (control and neuromuscular control (NMC)) for preventing knee injuries. A post-season self-report survey, derived from Health Belief Model constructs, included questions to obtain players’ views about the benefits and physical challenges of the programme in which they participated.

Results Compared with control players, those who participated in the NMC programme found it to be less physically challenging but more enjoyable and potentially of more benefit. Suggestions from players about potential improvements to the training programme and its future implementation included reducing duration, increasing range of drills/exercises and promoting its injury prevention and other benefits to players.

Conclusions Players provide valuable feedback about the content and focus of implemented exercise-training programmes, that will directly inform the delivery of similar, or more successful, programmes in the future.

BACKGROUND

For many years, researchers have investigated exercise-training strategies to potentially reduce the risk of anterior cruciate ligament (ACL) and other knee injuries in sport. Such injuries often occur during sporting tasks involving rapid changes of direction, rapid reduction in running speed and/or single-legged landing.1–4 Exercise-training strategies have attempted to teach athletes safe ways to perform these actions through approaches that can be broadly categorised as incorporating technique, plyometric, balance and/or resistance training.5 Most traditional football training sessions are designed to develop technical and tactical skills, whereas fitness training sessions emphasise the development of strength, power and/or endurance.6 To prevent injury, there is a need for training sessions to incorporate different neuromuscular and biomechanical approaches—including technique, balance training and plyometric training—towards learning safer ways of performing known tasks directly relevant to the sport.7–17 Evidence of the likely benefits of these different methods has come from a range of laboratory and field-based research studies.7–19 Although most evidence is from elite/high-performance athletes or women only, it is likely that it applies equally to other sport participants, where the same mechanisms of injury occur.20 A key limitation of the existing literature, however, is that few papers have published full details of their experimental exercise programmes and it has been difficult for others to replicate findings, or to implement the same programmes, in other settings. This contributes to the known implementation challenges of intervention adaptation and fidelity.21–26 Of course, neuromuscular training programmes aimed at community participants require effectiveness evidence when they are based on programmes previously developed for, and tested in, high performance sport. The pros and cons of different programme adaptations for community sport also need to be assessed and the likely barriers to, or drivers for, sustained adoption of these programmes by community players need to be identified and addressed, before they can be widely implemented.23,24

The first aim of this paper was to describe two variants of an exercise-training programme that were incorporated into the regular training schedules of 40 community Australian Football (AF) teams, over two consecutive playing seasons. One variant replicated common existing training practices (the control programme). The second variant (the neuromuscular control (NMC) programme) was derived from the evidence-base generated from a range of different studies that also included research on exercises in laboratory-based studies and population-based studies that were consistent with the mechanisms of injury and shown to alter biomechanical and/or neuromuscular factors related to decreasing the risk of sustaining injuries to the knee, particularly the ACL.
Successful exercise-training programmes require players to undertake them. This requires players to appreciate programme benefits, weighed against any perceived barriers that they may have towards undertaking them. The second aim of this paper is to compare players’ end-of-season views about these two programmes, to provide important information from the targeted end-users to inform the wide-scale implementation of similar programmes in the future. This study was nested within a larger group-clustered randomised controlled trial (RCT) of the effectiveness of the two programmes in preventing knee injuries.

**METHODS**

At community-level AF, most players undertake bi-weekly training sessions to prepare for their weekend games. These sessions focus on team tactics, technique modifications to enhance game skills and drills (aerobic, anaerobic and muscular endurance) to enhance fitness for the sport. Typically, these training programmes do not focus on specific exercises to reduce the risk of injury. The two programmes were designed to take place during the specific warm-up time of the training sessions, for approximately 20 min; as such their intensity was purposely designed not to be overly strenuous. Prior to conduct of these training programmes, players undertook a general warm-up including light running and stretching activities.

**Control training programme**

The control training programme was designed with the primary goal of mimicking common training programmes used in community AF. This focused on drills for running, jumping, landing, change of direction (COD) and agility. The difficulty of the exercises was graduated so that their demands increased over the season. Instruction on landing, agility or change-of-direction technique and balance tasks were not included in the control programme. Full details of the components of the programme are given in the online supplementary appendix 1.

**Development of the NMC training programme**

The evidence-base for the NMC programme aligned with the Translating Research into Prevention Practice framework, which states that a firm understanding of injury mechanisms is first required, and subsequent experimental evidence on counteracting any identified mechanisms should be used to guide potential injury prevention measures. The NMC programme was based on the then available scientific literature directly pertaining to ACL injuries in AF, but also borrowed from a range of ACL injury studies pertaining to other sporting codes. This experimental evidence came from a range of different types of investigations that included cadaveric-based research, computational models, analyses of videos of in-game ACL injuries, laboratory experiments of the manoeuvres that cause injury, and interventions that tested the effect of exercise/ neuromuscular training programmes on ACL injury prevention. Specifically, the NMC programme was designed to: fit within the real-world time confines of community-AF training sessions; improve sidestepping and/or single-leg landing technique in order to lower flexion, valgus and internal rotation moments at the knee; and increase muscular support of the knee. The programme incorporated balance, plyometric and technique activities.

The NMC programme aimed to ensure that correct technique was utilised during both sidestep cutting and landing movements. Specifically for sidestep, the aim was to achieve an upright forward facing torso with close foot placement, and increased knee flexion with a knee-over-toe posture. For landing, the players were instructed to keep their torso upright and to increase knee flexion. Plyometric and balance training were used to improve stability and control of whole body movements to reduce the valgus and internal rotation moments at the knee and increase the muscular support of these moments through both an increase in strength and co-contraction of muscles. Even in the plyometric and balance training, players were instructed to keep their torso upright, to increase knee flexion with knee-over-toe postures. All of the balance, plyometric and technique elements were deemed to be the guiding principles of the NMC training programme.

Online supplementary appendix 2 gives full details of the NMC programme including its progressions, exercise components and repetition/sets structure. In total, there were 20 exercises used throughout the season of four broad types: balance, basic movement, COD/agility and landing/mini-tramp activities. The programme included some progressions whereby the intensity and difficulty of the programme varied, beginning with less strenuous tasks and progressing in difficulty. A prime focus was on getting the players to perform the required exercises correctly and on eliciting desired neuromuscular and biomechanical changes.

For each exercise, key instructional points were emphasised by coaching staff, who were trained by authors (TD and DT) in how to deliver the training programmes. Key points were made specific to the exercise tasks and included cues from the coaches to achieve the desired techniques: avoid extraneous limb movement; concentrate on balance not the task; do not lean excessively with the trunk; keep the arms close to body; keep the contact foot in line with hips; maintain balance after task; maintain leg (shank) stability. These points often overlapped across exercises and built on each other throughout the season.

**Conduct of the Preventing Australian Football Injuries with eXercise RCT**

This study was nested within the conduct and evaluation of a group-clustered RCT of the effectiveness of exercise programmes in community AF: the Preventing Australian Football Injuries with eXercise (PAFIX) study. Full details of the study design, data collection protocol and accuracy of the data collection methods are published elsewhere. Briefly, PAFIX was a two arm group-clustered RCT conducted in community AF during the 2007 and 2008 playing seasons. Eighteen clubs from two Australian states (Victoria and Western Australia) nominated 40 teams to participate in the study and these groups of players were randomised to one of the two intervention arms, corresponding to the two programmes (control and NMC). All teams from the same club were randomised to the same study arm. A trained primary data collector was assigned to each team to deliver the training programme and collect data for the duration of the season. The study was approved by two Institutional Ethics Committees.

In both states, the programmes were started during presesason (8 weeks before the first game), delivered twice per week and continued in this fashion for the first half of the 18 round season (table 1). From season week 11, teams entered a maintenance phase and the programme delivery frequency was reduced to once per week. In total, teams participated in their allocated programme for 28 weeks, including two bye weeks. If teams made the finals series, their programme continued to run once per week for the remaining weeks up to a maximum of 4 weeks. Mesocycles lasted between 3 and 5 weeks when the training was twice per week (table 1).
Teams of players were randomly allocated to each trial arm and then players were recruited from randomised teams. Players were at least 18 years of age by the end of February in the year they were enrolled, and attended at least one training session in the 8-week preseason period or during the first 5 weeks of the season. Players who had not participated in any training sessions were excluded. Details of player attendance and their adoption of the programmes have been published elsewhere.25

End-of-season player survey
All players were invited to complete an end-of-season survey about their views on the specific training programme variant in which they had participated. The survey questions, which were worded identically for both study arms and included a mix of closed and open-ended questions, were derived from Health Belief Model constructs and based on an earlier survey used by the authors.24 The survey was administered over a 2-week period at all team training sessions at the end of the season (August–September). Players were encouraged to complete the surveys at a training session.

All surveys were pre-coded and double-entered. Thematic coding was applied to player responses to two open-ended questions. Eleven themes emerged from the question addressing how the training programme could be improved, and nine from the question addressing why players would want to participate in a similar training programme in the future. Most players provided brief single-idea responses but when they provided more than one, each response was coded separately. All data were analysed using the statistical software package, IBM SPSS Statistics V.20.

For each question, cross-tabulation tables of frequencies and percentages were produced. A two-sided Pearson $\chi^2$ test of association was used to ascertain any significant (p<0.05) differences in player responses across allocated programmes.

RESULTS
Overall, 1564 players participated in the PAFIX RCT. Of these, 442 players (or 28.3%) of the enrolled PAFIX players completed the voluntary post-season player survey. The response rate was the same in the two groups, with 192 players responding to the survey in relation to the NMC programme (of 679 players, 28.3%) and 250 (of 885 players, 28.2%) for the control programme.

The players from different programmes perceived different benefits (table 2). Significantly fewer NMC players agreed that their programme improved fitness than did control players. Conversely, a significantly greater proportion of NMC players, than control players, agreed that a benefit of this form of training programme was that it was more enjoyable than that previously undertaken.

Fewer NMC players thought their programme was harder than previous training, compared with control players (table 3). NMC players also thought that their programme was ‘more enjoyable than previous training’ and ‘better at preventing injury’.

When asked specifically about the intensity of their training, there was significantly proportionally more NMC players, than control players, who rated their programme as being of low intensity ($\chi^2=62.919$; p<0.001). Significantly fewer NMC players thought their programme was too long compared with the control group ($\chi^2=12.534$; p=0.006).

Players were asked if they thought their training programme could be improved in any way, 94 players (21.3%) gave specific suggestions for how this could be done. The most frequent responses for improvements to the programme were that it could be shorter in length (21% for NMC; 29% for control) and it could have more variety in the drills/exercises (16% for NMC; 18% for control).

Finally, the players were asked if they would choose to participate in a similar training programme in the future, and if so, why? Of the 209 players (47.2% of the survey respondents) who answered yes, 116 (56%) players gave reasons (table 4); ‘preventing injury’ (33% for NMC; 20% for control) and

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**Table 1** Intervention delivery plan

<table>
<thead>
<tr>
<th>Week</th>
<th>Programme</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weeks 1–4 preseason</td>
<td>Pre 1</td>
<td>2/week</td>
</tr>
<tr>
<td>Weeks 5–8 preseason</td>
<td>Pre 2</td>
<td>2/week</td>
</tr>
<tr>
<td>Weeks 1–5</td>
<td>In-season 1</td>
<td>2/week</td>
</tr>
<tr>
<td>Weeks 6–10</td>
<td>In-season 2</td>
<td>2/week</td>
</tr>
<tr>
<td>Weeks 11–14</td>
<td>Maintenance 1</td>
<td>1/week</td>
</tr>
<tr>
<td>Weeks 15–18</td>
<td>Maintenance 2</td>
<td>1/week</td>
</tr>
<tr>
<td>Weeks 19–22</td>
<td>Maintenance 3</td>
<td>1/week</td>
</tr>
</tbody>
</table>

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**Table 2** Players’ opinions about the benefits of the exercise training they participated in: control (n=250) or neuromuscular control (NMC; n=192)

<table>
<thead>
<tr>
<th>Player response</th>
<th>Programme</th>
<th>It improved my performance</th>
<th>It reduced my risk of injury</th>
<th>It increased my enjoyment of the game</th>
<th>It improved my fitness</th>
<th>It made me enjoy training more</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagree</td>
<td>NMC</td>
<td>5 (2.6%)</td>
<td>5 (2.6%)</td>
<td>9 (4.7%)</td>
<td>7 (3.6%)</td>
<td>8 (4.2%)</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>14 (5.6%)</td>
<td>16 (6.4%)</td>
<td>23 (9.2%)</td>
<td>13 (5.2%)</td>
<td>22 (8.9%)</td>
</tr>
<tr>
<td>Disagree</td>
<td>NMC</td>
<td>24 (12.5%)</td>
<td>15 (7.8%)</td>
<td>36 (18.8%)</td>
<td>34 (17.2%)</td>
<td>29 (15.1%)</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>36 (14.4%)</td>
<td>24 (9.6%)</td>
<td>51 (20.5%)</td>
<td>32 (12.9%)</td>
<td>51 (20.7%)</td>
</tr>
<tr>
<td>Neither agree nor disagree</td>
<td>NMC</td>
<td>96 (50.0%)</td>
<td>59 (30.7%)</td>
<td>98 (51.0%)</td>
<td>74 (38.5%)</td>
<td>84 (43.8%)</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>108 (43.2%)</td>
<td>77 (30.8%)</td>
<td>113 (45.4%)</td>
<td>69 (27.7%)</td>
<td>111 (45.1%)</td>
</tr>
<tr>
<td>Agree</td>
<td>NMC</td>
<td>61 (31.8%)</td>
<td>97 (50.5%)</td>
<td>43 (22.4%)</td>
<td>66 (34.4%)</td>
<td>62 (32.3%)</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>82 (32.8%)</td>
<td>110 (44.0%)</td>
<td>51 (20.5%)</td>
<td>116 (46.6%)</td>
<td>50 (20.3%)</td>
</tr>
<tr>
<td>Strongly agree</td>
<td>NMC</td>
<td>6 (3.1%)</td>
<td>16 (8.3%)</td>
<td>6 (3.1%)</td>
<td>11 (5.7%)</td>
<td>9 (4.7%)</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>10 (4.0%)</td>
<td>23 (9.2%)</td>
<td>11 (4.4%)</td>
<td>19 (7.6%)</td>
<td>12 (4.9%)</td>
</tr>
</tbody>
</table>

χ² test of association across programmes:

- NMC: $\chi^2=3.909$ (p=0.418)
- Control: $\chi^2=4.765$ (p=0.312)
- NMC and Control: $\chi^2=10.717$ (p=0.030)
‘being a beneficial program’ (20% for NMC; 12% for control) which were the most frequently stated reasons.

DISCUSSION

There is increasing awareness of the challenges of implementing evidence-based programmes in the delivery context of community sport.\(^4\) While there is no strong evidence to underpin such programmes, the quality of evidence supporting exercise-training programmes for lower limb injury prevention is variable.\(^5\) Most studies have not provided specific implementation details, and this has limited the extent to which similar programmes can confidently be applied in other settings. This paper is one of very few to provide specific information about the content and delivery of an exercise-training programme aimed at lower limb injury prevention in any form of community football. In doing so, it provides a strong basis from which programme adaptations could be made and tested to inform future programmes.

Both programme variants were designed using typical programming principles, such as progressive overload and periodisation. For example, the intensity and difficulty of the exercises increased and fluctuated throughout the season. In the NMC programme, simple exercises such as ‘squares’ were programmed in the first weeks and mini-tramp exercises were not introduced until week 9, that is, the more physically challenging and demanding exercises were only introduced after a suitable base and proficiency had been established.

Having an evidence-based programme that can be adapted for different delivery settings is a necessary condition for broader implementation, but it is not sufficient. In the end, the programmes need to be both adopted by coaches or fitness/skills trainers as the delivery agents and undertaken by players as the programme participants. Evidence-based NMC programmes need to be both adopted by coaches or fitness/skills trainers as the delivery agents and undertaken by players as the programme participants. Evidence-based programmes aimed at lower limb injury prevention exercise-training programmes for their sport before they had participated in such a programme.\(^24\) The views of those players were generally that their programme improved fitness and hence were, by design, not of high intensity, which is as expected given the NMC was of low intensity than the control programme. It is worth pointing out that the implemented programmes were not aimed at improving fitness and hence were, by design, not of high intensity; they were intended to be undertaken as a warm-up before regular training components. Nonetheless, the same NMC players thought that their programme made training more enjoyable and this possibly reflects the novelty of the equipment and specific exercises for many players. Overall, compared with previous training programmes they had participated in, the

Table 3

<table>
<thead>
<tr>
<th>Programme type</th>
<th>Of more benefit to your performance</th>
<th>More relevant to the game</th>
<th>Harder</th>
<th>Better at preventing injury</th>
<th>Boring</th>
<th>More enjoyable</th>
<th>More of a challenge</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>113 (43.5%)</td>
<td>57 (21.4%)</td>
<td>31 (11.8%)</td>
<td>12 (4.5%)</td>
<td>17 (6.3%)</td>
<td>56 (21.4%)</td>
<td>35 (13.1%)</td>
</tr>
<tr>
<td>Yes</td>
<td>67 (31.0%)</td>
<td>48 (22.1%)</td>
<td>21 (10.0%)</td>
<td>18 (8.8%)</td>
<td>37 (17.5%)</td>
<td>57 (27.0%)</td>
<td>25 (12.2%)</td>
</tr>
<tr>
<td>Same</td>
<td>76 (38.5%)</td>
<td>30 (15.3%)</td>
<td>23 (11.5%)</td>
<td>12 (6.2%)</td>
<td>33 (16.9%)</td>
<td>48 (24.3%)</td>
<td>16 (8.2%)</td>
</tr>
<tr>
<td>Don’t know</td>
<td>72 (36.0%)</td>
<td>44 (22.0%)</td>
<td>20 (10.0%)</td>
<td>16 (8.2%)</td>
<td>37 (18.5%)</td>
<td>53 (26.5%)</td>
<td>21 (10.5%)</td>
</tr>
<tr>
<td>Statistical comparison across programmes: (\chi^2=2.36) (p=0.28)</td>
<td>(\chi^2=0.98) (p=0.33)</td>
<td>(\chi^2=0.98) (p=0.33)</td>
<td>(\chi^2=0.98) (p=0.33)</td>
<td>(\chi^2=0.98) (p=0.33)</td>
<td>(\chi^2=0.98) (p=0.33)</td>
<td>(\chi^2=0.98) (p=0.33)</td>
<td>(\chi^2=0.98) (p=0.33)</td>
</tr>
</tbody>
</table>
NMC players were more likely to consider their programme as being more enjoyable, less hard and better at preventing injury than did control players.

Having players participate in a programme is only the first stage in ensuring long-term injury prevention goals. As reported elsewhere, these players had variable attendance at training sessions across the season, but if they did attend training, they were highly likely to participate in the programme.25 However, for long-term injury prevention goals, players need to adopt these behaviours consistently and attention needs to be given towards likely drivers of maintenance of player participation.40

For this reason, players were invited to suggest improvements to the programme. The most common suggestion was for the programmes to be decreased in length, presumably, so players could move on to what they considered the main focus of their training to be, that is, football-specific skills and fitness development. This was unexpected feedback, as the programmes were designed to be the length of the usual warm-up periods before normal training. The trialled programmes were designed to last for up to 20 min, though most were completed in 15 min. The final 2–3 warm-up activities included match-specific activities for dual use of the time (ie, for both warm-up and basic skill training).

The second most common suggestion was to have more variety in the drills/exercises. This would certainly be advantageous to ensure players are neither bored nor under-challenged by the exercises and to help reduce player dropout. There is a role for coaching staff to engage with players actively in this aspect. The specific training drills shown in the appendices provide a starting point from which coaches can consider exercise variations. However, it will be important that modifications, if any, maintain the principles of training programmes and are delivered with high fidelity to ensure that intended injury prevention benefits flow. Such changes should be made by personnel qualified to design training programmes and those with suitable experience to ensure that any modified programme delivers the same benefits as the original programme. Importantly, any modified programme must still include all three components of balance, plyometrics and technique and ensure instruction points/cues are used to emphasise correct sidestep and landing movements.

It is particularly pleasing that the highest proportion of players, from both programmes, indicated that the major reason to motivate them to undertake their training programmes in the future was its likely injury prevention benefits. The fact that this benefit was a stronger motivator for the NMC players suggests that, at the very least, they perceived a sense of protection from injury for having completed the NMC programme.

This study has several limitations. It was nested within a larger RCT and so the number of players available to complete the end-of-season survey was limited by the number who attended training sessions at the end of the season. Unfortunately we have no information about why players did or did not attend training sessions towards the end of the season, but one possible reason for non-attendance could be related to the likelihood of the players’ teams progressing to the final series.25 The overall response rate, in proportion to all enrolled trial players, was 28% but as this was consistent across study arms there was unlikely to be a differential response according to the nature of the specific training programme delivered. However, we have previously described attendance of the players in the training sessions throughout the season and shown that at most only 40% of them attended training in the final 4 weeks of the season, when this survey was conducted.25 Taking this into account, the survey response rate is close to 71% of all players who attended training at the end of the season, indicating a good capture of players’ views in the survey. Unfortunately, we do not have information about the non-responders’ views of the training programmes and it is possible that they could be different to what is reported here.

All information collected in the surveys reflect the subjective views of the players and their self-assessments of the training programmes. As such, their rating of programme intensity, etc will be subjective and it was not possible to confirm this with

### Table 4
Themes coded from players’ free-text suggestions for improvements to the training programmes and stated motivators for their ongoing participation in a similar training programme

<table>
<thead>
<tr>
<th>Suggested improvements that could be made to the training programme</th>
<th>Programme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shorter in length</td>
<td>NMC n (% of responders to question)</td>
</tr>
<tr>
<td>More variety in drills/exercises</td>
<td>8 (21)</td>
</tr>
<tr>
<td>Higher intensity/more active</td>
<td>6 (16)</td>
</tr>
<tr>
<td>More specific to football/game play</td>
<td>6 (16)</td>
</tr>
<tr>
<td>Better/frequent explanation of drills/benefits of programme</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Gradual exposure to sprints</td>
<td>2 (5)</td>
</tr>
<tr>
<td>More equipment</td>
<td>0</td>
</tr>
<tr>
<td>More enjoyable/interesting</td>
<td>1 (3)</td>
</tr>
<tr>
<td>More stretching/core/balance/interval training</td>
<td>3 (8)</td>
</tr>
<tr>
<td>Other/non-specific</td>
<td>2 (5)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reasons for future participation in a similar training programme</th>
<th>Programme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevent injury</td>
<td>NMC n (% of responders to question)</td>
</tr>
<tr>
<td>Beneficial</td>
<td>17 (33)</td>
</tr>
<tr>
<td>Improves fitness</td>
<td>10 (20)</td>
</tr>
<tr>
<td>Good warm-up/prepares body for training</td>
<td>0</td>
</tr>
<tr>
<td>More interesting/good change from normal warm-up</td>
<td>4 (8)</td>
</tr>
<tr>
<td>Helps with ability/balance</td>
<td>7 (14)</td>
</tr>
<tr>
<td>Good/enjoyable</td>
<td>4 (8)</td>
</tr>
<tr>
<td>Benefits performance/makes me a better player</td>
<td>3 (6)</td>
</tr>
<tr>
<td>Other/non-specific</td>
<td>6 (12)</td>
</tr>
</tbody>
</table>

Responses given as frequencies and percentages of each group who answered this question. NMC, neuromuscular control.
direct observation. Suggestions about how to improve the programmes and their delivery were only given by a subset of players. Nonetheless, suggestions they gave about what would motivate them to continue with the programme will be valuable for informing future prevention programmes.

In summary, this paper has presented details of two variants of an exercise-training programme and the views of the players who participated in either form. Players are the targeted end-users and beneficiaries of exercise-training programmes implemented during coach-led training sessions. Their views about the programmes are important because they are necessary for directly informing the delivery of similar, or more successful, programmes in the future. As the programmes are delivered by coaching staff, establishing the views of coaches, and how they relate to those of their players, will also be important.

What are the new findings

- In order to ensure sustained adoption of evidence-based exercise-training programmes, views need to be obtained from players (the end-beneficiaries) as to the likely barriers against, or drivers, of this.
- Compared with players who participated in standard training programmes, players who participate in a neuromuscular control (NMC) exercise-training programme find it less physically challenging but more enjoyable and potentially of more benefit than previous programmes. This stresses the importance of training in community sports.
- Future neuromuscular training programmes can be modelled on the detailed programme provided in this paper but, to maximise player engagement with them, consideration should be given to its timing and intensity within the overall training session, increasing the range of drills/exercises that can be undertaken and widely promoting its injury prevention and other benefits to players.

How might it impact on clinical practice in the near future

- The proposed neuromuscular control (NMC) exercise-training programme has sufficient detail to be directly implemented, especially in Australian football.
- The training principles of the NMC programme can be adapted to other sporting codes and motivate the development of new training programmes.
- New designs of injury prevention programmes may need to increase difficulty of progressions.
- Emphasising the injury prevention benefits of training programmes to players will ensure uptake and adherence.

Acknowledgements Angela McGlashan is thanked for her contributions as research assistant on this project through the conduct of the surveys in the Victorian sample and for helping to establish the survey database.

Contributors CFF, DGL and BCE conceived and designed the PAFIX study, CFF, TLAD and ARD took the lead roles in writing the paper. Each coauthor contributed to the writing of the paper and/or provided significant editorial inputs. DMT and TLAD recruited the clubs and players and oversaw the delivery of the programme. TLAD designed the training programme components, under direction from DGL and BCE. TLAD administered the surveys in the WA sample. KD and PEW undertook database management, data coding and analysis, and developed the analysis plan in conjunction with CFF. WY contributed to the interpretation of the data.

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Abbreviations:
SLS = Single leg stance
DLS = Double leg stance
DL = Double leg
SL = Single leg
EO = Eyes open
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HB = Head back
COD = Change of direction
PP = Pre-planned
UP = Un-planned

Conventions
Jump = Two legged movement
Hop = One legged ipsi-lateral i.e., left leg to left leg
Bound = One legged contra-lateral i.e., left leg to right leg

Asterisks beside exercises indicate these exercise can be run concurrently.
Some programs have 1 or 2 asterisks, in this case only run exercises concurrently with the same number of asterisks.
Basic Movement Exercises

Squares (10 m)

Players run as indicated in diagram

Equipment

- Cones
- Dura discs

Key point

- Smooth transition between running tasks
**Weaving Bounds (a)**

Cones are placed 1 m apart in the direction of movement

Channel through which players bound is about 2 m wide

Length of cones is about 10 metres

Players are to bound weaving from cone to cone

Bounding speed is moderate pace

**Equipment**

- Cones

**Key point**

- Emphasise forward running speed
**Weaving Bounds (b)**

Cones are placed 1 m apart in the direction of movement
Length of cones is about 10 metres
Channel through which players bound is larger than previous exercise, > 2 m

Bounding speed is moderate to fast pace

**Equipment**

- Cones

See previous diagram. Adjust distances as needed.

**Key point**

- Emphasise forward running speed
**Shuttle Runs**

Cones are placed in a square outlining a 20 m distance

1 rep is up and back

Players run up and back for required number of reps at moderate-fast pace

**Equipment**

- Cones

---

**Key point**

- Quick turnaround at top
*Bunny Jumps*

Using a powerful arm swing to help propel forward players jump forward for required number of jumps

**Equipment**

- N/A

**Key point**

- Quick transition between jumps
**Standing Triples**

Players perform a hop, skip, and jump from a standing start
Players should try to jump further with each rep

**Equipment**

- N/A

**Key point**

- Quick transition between each rep
**General Sprinting Exercises**

**Sprints (Lying Start)**

Players start lying on their stomach with feet pointing in direction to run
On command players get up as quick as possible and run over required distance
Walk back to start for recovery

**Equipment**

- Cones

![Diagram of sprinting exercises]

**Key point**

- Quick transition from lying to standing
**Resisted Sprints (5+15m)**

Player behind the sprinter grabs their waist
The sprinter is resisted for the first 5 m and is to emphasise leg drive and stride rate
Both are to move forward to the 5 m mark
At the 5 m mark the sprinter is realised and sprints maximally for 15 m
Sprinter is to run with ball in hand

**Equipment**
- Cones
- Footballs

**Key point**
- Emphasise forward body lean and short, quick strides
**Tempo Runs**

Exercise is performed over a total distance of 40 m
The first 10 m requires players to perform one of a number of drills

- Ankling
- Walking/Skipping A's
- Stiff leg pull throughs
- Grapevine
- Side-to-side

These drills are to be varied by trainer as required
After the drill players accelerate and sprint the last 30 m as fast as possible
Maintain good sprinting technique

**Equipment**

- Cones

**Key point**

- Emphasis on the drill at the start
Acceleration/Deceleration Exercises

Kneeling Beach Sprints

One on knee
Rear foot must be flat
Push off front foot going up and forward
Trailing foot/leg must be strong to support weight on 1st step
Maintain sprinting technique
Handicap players if necessary (i.e., faster ones start behind)
Look for good lean at start

Equipment

- N/A

Key point

- Quick transition from one knee to up
**Graduated Sprints (20m)**

Players run and accelerate at each check point  
Emphasise a sudden change in speed at 5, 10, 15 m  
At 15 m players should be running maximally

**Equipment**

- Cones

**Key point**

- Emphasise sudden speed changes at each marker
**Stoppies (10+2m)**

Players run as fast as they can for 10 m
They must come to a complete stop within 2 m after the 10 m

**Equipment**

- Cones

![Diagram](image)

**Key point**

- Must stop abruptly in 2 metre
COD/Agility Exercises

PP COD

With prior knowledge of which way to cut players run up the middle and cut left or right

Players are to run with a ball in their hands

Equipment

- Cones
- Footballs

Key point

- Complete task as fast as possible
**UP COD (180 Turn)**

*Without* prior knowledge of which way to cut players run up the middle and are directed by a stimulus which way to cut.

Stimulus is trainer that points to the direction of cut (run with ball in hand)

After making cut players make a 180 turn back to start as quickly as possible

**Equipment**

- Cones
- Footballs

---

**Key point**

- Respond as quickly as possible to trainer/player’s command
**PP COD (Double Forward)**

With prior knowledge of which way to cut players run up the middle and cut left or right, then cut right or left

i.e., if players first cut to the left they follow this with a cut to the right and vice versa

Players are to run with a ball in their hands

**Equipment**

- Cones
- Footballs

**Key point**

- Emphasise sharp sudden COD
**Backpedals (a) (15m)**

Players backpedal (run backwards) for 15m

When they reach the end they sprint forward to the start as fast as possible

**Equipment**

- Cones

![Diagram](image)

**Key point**

- Emphasise sharp sudden COD and good forward sprinting technique
**Backpedals (b) (15m)**

Players backpedal (run backwards) for 15m

When they reach the end they turn 90° and sprint to the side

Vary side to run to as required

**Equipment**

- Cones

![Diagram of backpedals]

**Key point**

- Emphasise sharp sudden 90° turn
**T-test**

Players run through a standard T-test

Run forward around cone, turn 90 degrees left (or right), run forward, turn 180 degrees around cone, run past the middle cone, turn 180 degrees around the end, back to the middle turn 90 degrees and run back to the start.

**Equipment**

- Cones

---

**Key point**

- Complete task as quickly as possible
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Asterisks beside exercises indicate these exercise can be run concurrently.
Some programs have 1 or 2 asterisks, in this case only run exercises concurrently with the same number of asterisks.
Basic Movement Exercises

Squares (10 m)

Players run as indicated in diagram
After completing the running component they complete a balance task that can be modified to match skill as necessary
i.e., DLS (HB) 20 sec

Equipment
- Cones
- Dura discs

Key points
- Smooth transition between running tasks
- Maintain balance on balance task
**Weaving Bounds (a)**

Cones are placed 1 m apart in the direction of movement
Length of cones is about 10 metres
Channel through which players bound is about 2 m wide

Players are to bound weaving from cone to cone
Bounding speed is moderate pace

**Equipment**
- Cones

Key points
- Smooth transition between bounds
- Maintain stable upper body i.e., no leaning
Weaving Bounds (b)

Cones are placed 1 m apart in the direction of movement
Length of cones is about 10 metres
Channel through which players bound is larger than previous exercise, > 2 m

Players are to bound weaving aggressively from cone to cone
Bounding speed is moderate to fast pace
Players are provided with instruction as to how best to weave
  i.e., body upright, no twisting, keeping foot close to mid-line

Equipment

- Cones
  See previous diagram. Adjust distances as needed.

Key points

- Sharp/hard bounds from cone to cone
- Smooth transition between bounds
- Maintain stable upper body i.e., no leaning
**Weaving Hops**

Cones are placed < 1 m apart in the direction of movement
Length of cones is 10 metres
Channel through which players run is narrower than previous exercise, ~ 1 m

Players are to hop on same leg from cone to cone
Players are provided with instruction as to how best to weave
    i.e., body upright, no twisting, keeping foot close to mid-line

**Equipment**

- Cones
  
  See previous diagram. Adjust distances as needed.

**Key points**

- Smooth transition between hops
- Maintain stable upper body i.e., no leaning
- Maintain lower leg stability i.e., no wavering of knee
Balance Exercises

Dura-Disc Balance

Players are to maintain balance on dura disc for specified amount of time.

Variations to this exercise include

DLS/SLS
EO/EC
HB

Equipment

- Dura disc

Key points

- Must concentrate to complete required time
- Maintain balance with as little movement of arms/legs as possible
**Wobble Board Balance**

Players to maintain balance on a wobble board for specified amount of time.

Variations to this exercise include:

- Double leg stance (DLS)
- Single leg stance (SLS)
- Eyes Open (EO)
- Eyes Closed (EC)
- Head back (HB)

**Equipment**

- Wobble board

**Progressions**

Tasks can be made more difficult by including movements of arms, legs, etc. as players improve. For hand passing drills target outside of body, and touch further away. Increase speed of movements.

**Key points**

- Must concentrate to complete required time
- Maintain balance with as little movement of arms/legs as possible
**Balance Hand Passing**

Conducted in pairs, players hand pass to each other over a distance of 10 meters for a specified amount of time.

Variations of this drill include:
- Touching the ball to the ground in between passes
- Standing on a wobble board/dura disc

**SLS/DLS**

**Equipment**

- Footballs
- Wobble board

**Key points**

- Focus on maintaining balance and not pass
- Must maintain balance with as little extraneous movement of arms/legs as possible
**Balance Kicking**

Conducted in pairs, players kick to each other over a distance of 10 meters for a specified amount of time

Usually conducted as SLS but can vary with DLS as skill dictates

**Equipment**

- Footballs
- Dura disc

**Key points**

- Focus on maintaining balance and not kick
- Must maintain balance with as little extraneous movement of arms/legs as possible
Hopping Exercises

Dura-Disc Hop

Hop onto dura disc hold SLS balance for period of time
Can vary balance after hop as per usual Dura Disc Balance
Time to hold balance on dura disc may be specified

Equipment

- Dura disc

Key points

- Must maintain balance after hop
- Keep extraneous arm and leg movement to a minimum
Hurdle Jumps

Continuous jumping over hurdles

Equipment

- Hurdles

Key points

- Smooth transition between jumps
- Flex knees to absorb landing
- Maintain lower leg stability i.e., no wavering of knee
**Lateral Hurdle Jumps**

Players jump forward/backward over hurdles then side/side (left) and side/side (right)

Instruction is provided regarding technique as usual

**Equipment**

- Hurdles

**Key points**

- Flex knees to absorb landing
- Keep extraneous arm and upper body movement to a minimum
- Maintain lower leg stability i.e., no wavering of knee
Hurdle Jump (PP Step)

Players jump forward over hurdle then immediately perform a step to left or right

Knowledge about step direction is given prior to task
Instruction is provided regarding technique as usual
Player can run with ball in hand

Equipment

- Hurdles
- Football

Key points

- Flex knees to absorb landing
- Keep foot close to hips
**Hurdle Jump (UP Step)**

Players jump forward over hurdle then immediately perform a step to left or right

Knowledge about step direction is *not given* prior to task

Stimulus is handball to side or,

Stimulus is trainer/player pointing

Instruction is provided regarding technique as usual

**Equipment**

- Hurdles
- Football

**Key points**

- Smooth transition from hop to step
- Avoid excessive upper body movement
- Keep foot close to hips
**Hurdle Hop**

On a single leg players hop continuously forward over hurdles

Number of hurdles is pre-determined (about 5)

Players alternate legs with each set

**Equipment**

- Hurdles

**Key points**

- Avoid excessive upper body movement
- Maintain lower leg stability i.e., no wavering of knee
- Flex knees to absorb landing
Change of Direction Exercises

**PP COD**

With prior knowledge of which way to cut players run up the middle and cut left or right

Players are provided with instruction with respect to their COD technique

Players are to run with a ball in their hands

**Equipment**

- Cones
- Footballs

![Diagram of PP COD exercise setup]

**Key points**

- Avoid excessive upper body movement i.e., no leaning
- Keep arms close to body
- Keep foot close to hips
**UP COD**

*Without* prior knowledge of which way to cut players run up the middle and are directed by a stimulus which way to cut. Stimulus is handball to side or, Stimulus is trainer/player pointing (run with ball in hand)

Players are provided with instruction with respect to their COD technique

The task can be made more difficult by placing hurdles at start of task

**Equipment**

- Cones
- Footballs
- Hurdles

**Key points**

- Avoid excessive upper body movement i.e., no leaning
- Keep arms close to body
- Keep foot close to hips
**UP COD (180 Turn)**

*Without* prior knowledge of which way to cut players run up the middle and are directed by a stimulus which way to cut.

Stimulus is defensive player that must be avoided (run with ball in hand)

After making cut players make a 180 turn back to start as quickly as possible

Players are provided with instruction with respect to their COD technique.

**Equipment**

- Cones
- Footballs

**Key points**

- Avoid excessive upper body movement i.e., no leaning
- Keep arms close to body
- Bend knees for turning
Swiss Ball Exercises

SB Kneeling

Using a base for the Swiss ball players are to balance on ball for specified period of time

Variations include

No base, but partner to assist when needed

Equipment

• Swiss ball
• Support base

Key points

- Concentrate to complete task
- Avoid excessive arm movement
- Avoid excessive trunk movement
**SB Squat**

Players are to balance in a semi-squat on ball for specified period of time

A partner can assist when needed

**Equipment**

- Swiss ball

**Key points**

- Concentrate to complete task
- Avoid excessive arm movement
- Avoid excessive trunk movement
Mini-tramp Exercises

Mini-Tramp Land

Players are to jump or hop onto the min-tramp and land with good technique. Instruction is provided regarding technique as usual. Can be performed as a DL or SL drill.

Equipment

- Mini-tramp
- Footballs

Progressions

Tasks can be made more difficult by including movements of arms, legs, etc. as players improve. For hand passing drills target outside of body, and touch further away. Increase speed of movements. DL movements may progress to SL. Mini-tramp can increase lateral distance of jump.

Key points

- Bend knees to absorb landing
- Avoid excessive trunk movement
- Keep arms close to body
**Mini-Tramp Land (Lateral Hop)**

Players are to jump or hop onto the min-tramp and land. Immediately after landing they are to laterally hop to left or right as per prior instruction.

Drill is conducted with ball in hand.
Instruction is provided regarding technique as usual.

**Equipment**
- Mini-tramp
- Footballs
- Hurdles

**Key points**
- Bend knees to absorb landing
- Don’t lean upper body
- Stop excessive forward motion
**Mini-Tramp Land (Hop, Step)**

Players are to jump onto the min-tramp and land
Immediately after landing they are to hop forward and then step left or right as per stimulus
Stimulus is handball to side or,
Stimulus is trainer/player pointing (run with ball in hand)
Instruction is provided regarding technique as usual

**Equipment**

- Mini-tramp
- Footballs
- Hurdles

**Key points**

- Bend knees to absorb landing
- Keep arms close to body
- Keep foot close to hips
**Mini-Tramp Land (Catch, Step)**

Players are to jump/hop onto the min-tramp and land

As they are landing a ball will be hand passed indicating direction to cut

Instruction is provided regarding technique as usual

**Equipment**

- Mini-tramp
- Footballs

![Diagram of Mini-Tramp Land (Catch, Step)](image)

**Key points**

- Bend knees to absorb landing
- Keep arms close to body
- Keep foot close to hips