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Classification of players across the Australian Rules football participation pathway based on physical characteristics

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Response to Reviewers:	Reviewer Comments: Reviewer #1: The authors have done a good job at responding to comments. Well done!

Reviewer #2: No additional comments
We would like to thank the reviewers for their time and kind feedback regarding this study. It is much appreciated.

Note from Senior Associate Editor

Thank you to the Senior Associate Editor for highlighting these formatting oversights. The suggested changes have been made throughout the manuscript
•Please add a section/sub-heading at the start of the Methods section "Experimental Approach to the Problem (see author guidelines). Other sub-headings also need to be added.
oThe correct Methods subheadings have now been added to the manuscript (pages: 5-7).

•Check that you have used US spelling throughout e.g. prioritized.
oThe spelling has now been changed US throughout the manuscript.

•Please add some more to the Practical Applications section. How can strength and conditioning practitioners use your results?
oWe agree with the Senior Associate Editor and the following has now been added to the Practical Applications section (page: 15, lines: 352-356):

"Furthermore, strength and conditioning practitioners may identify players that are under-performing in key physical fitness and/or movement abilities important for their competition level. This would provide more informed and individualized strength and conditioning programs for players at varying development stages within the same AFL participation pathway level."

•References need to be formatted to the JSCR submission guidelines. Pay particular attention to journal names.
oApologies for this oversight. The references have now been changed to the correct format.

8th July, 2019

To the Editors,
Journal of Strength & Conditioning Research

Category: Original Research
Title of manuscript: Classification of players across the Australian Rules football participation pathway based on physical characteristics

Please find attached the abovementioned manuscript for submission to *Journal of Strength & Conditioning Research.*

This manuscript is original and not previously published in any form including on preprint servers, nor is it being considered elsewhere until a decision is made as to its acceptability by the JSCR Editorial Review Board.

The attached manuscript has been read and approved by all the listed co-authors below. All co-authors meet the requirements of co-authorship as specified in the Authorship Guidelines provided by the Journal of Strength & Conditioning Research. Funding and financial support was provided by the Australian Football League Research Board. The Australian Football League Research Board also provided access to their databases for analysis by the research team. The proposed manuscript does not concern any commercial product. The authors report no conflicts of interest with information reported within this study.

We look forward to a positive review of our paper. Should you require any further information relating to the methods used in the study please do not hesitate to contact the corresponding author.

Yours sincerely,

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Classification of players across the Australian Rules football participation pathway based on physical characteristics

Original Investigation

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ABSTRACT

This study investigated the utility of physical fitness and movement ability tests to differentiate and classify players into Australian Football League (AFL) participation pathway levels. Players (n = 293, age 10.9 – 19.1 years) completed the following tests; 5-m, 10-m and 20-m sprint, AFL planned agility, vertical jump (VJ), running vertical jump, 20-m Multi-Stage Fitness Test (MSFT), and Athletic Ability Assessment (AAA). A multivariate analysis of variance between AFL participation pathway levels was conducted, and a classification tree determined the extent to which players could be allocated to relevant levels. The magnitude of differences between physical fitness and movement ability were level dependent, with the largest standardized effects (ES) between Local U12, Local U14s, and older levels for most physical fitness tests (ES: -4.64 to 5.02), except the 5-m and 10-m sprint. The 20-m, 5-m, AFL agility, 20-m MSFT, overhead squat, and running VJ (right) contributed to the classification model, with 57% overall accuracy reported (43% under cross-validation). National U16 players were easiest to classify (87%), while National U18 were most difficult (0%). Physical fitness tests do not appear to differentiate between players following selection into AFL talent pathway levels. Other attributes (i.e., skill, psychological, and socio-cultural) should be prioritized over physical fitness and movement attributes by selectors/coaches when considering selection of talented players.

Keywords: Talent identification, team sport, classification modelling, physical fitness, sport development pathway

24 **INTRODUCTION**

25 The Australian Football League (AFL) is a professional sport that implements a draft and salary

26 cap system to facilitate equitable competition. On this basis, talent identification and

27 development of players is multidimensional and requires consideration from both performance

28 and economic perspectives (21). The current AFL participation pathway involves two streams;

29 the local participation pathway and talent pathway. The local participation pathway consists

30 of; school/clubs/community teams (5-18 years of age), and open age league/associations (>18

31 years), while talent pathways comprise a smaller cohort of talent identified junior players (9).

32 Generally, player selection into the talent pathway is based on objective test outcomes such as

33 physical fitness and skills testing, and subjective match performance assessments conducted

34 by coaches and talent scouts (32, 33). Players may be selected into senior competitions from

35 either the participation or talent pathways, with elite players primarily selected through the

36 annual AFL National Draft (22). While the structure of the AFL participation pathway may

37 provide clear local participation and talent pathways for players, no studies have assessed the

38 differences in physical fitness profiles between multiple levels of the local participation and

39 talent pathways. Understanding the physical differences between local and talent pathways is

40 important for short-term player development as it allows the implementation of training plans

41 that are specific to the physical capacities of players at each AFL participation pathway level.

42 Additionally, short-term training plans may also be tailored to AFL participation pathway

43 levels with the aim of building the physical foundations required for long-term player

44 development.

45 Talent identification and development are multi-dimensional, encompassing aspects of

46 physical fitness (21), tactical and technical skills (1), psychological characteristics (18), and

47 socio-cultural influences (3, 6). However, traditional talent identification in professional sports

48   is typically cross-sectional in nature, with selection of junior athletes based on current sport

49   performances, physical fitness, and anthropometric characteristics (19). The predictability and

50   usefulness of cross-sectional talent identification models is often poor because they usually

51   involve player selection for short-term success in junior competition, not long-term player

52   development (8, 19, 25). Combining pressure for short-term success within junior competition

53   and the natural variability of performance and development of adolescent athletes can influence

54   player likelihood of selection/deselection into talent pathways (19). As such, it is important to

55   understand the long-term physical development pattern of players as they transition through

56   the AFL participation pathway.

57   Match performance of adolescent players is influenced by their physical and anthropometric

58   maturity; early maturing players are likely selected into the talent pathway given their

59   perceived physical advantage, placing late maturing players at a selection disadvantage (27,

60   32, 36). The representative selection policies used by the AFL may have some limitations to

61   athlete retention because they lack the flexibility to account for long-term athlete development

62   (19, 25). However, valid research involving longitudinal tracking of athletes in relation to talent

63   identification and elite athlete development is limited (10, 11). This shortcoming may be

64   attributed to sacrificing long-term development objectives, in favor of short-term performance

65   outcomes valued by junior coaches and clubs (19). Further, the development of players is

66   typically non-linear with multiple factors influencing football performance (19, 25). As such,

67   the use of non-linear analysis to classify players (as opposed to linear methods) may identify

68   varying combinations of physical fitness attributes which contribute to a player's likelihood of

69   selection into AFL talent pathways.

70   The annual AFL National Draft Combine physical testing battery forms part of the AFL's talent

71   identification process and includes the following; 20-m sprint, vertical jump (VJ) variations,

72   AFL planned agility run, and multi-stage fitness test (MSFT) (22, 23, 32). These tests have

73   shown to be useful for tracking career progression, recruiting trends, and selecting players for

74   specific positions (22). Substantial differences in 20-m sprint, VJ, and 20-m MSFT are evident

75   between selected and non-selected players at state and national levels within the AFL talent

76   pathway (27, 32, 36). Similar findings were reported between AFL drafted and junior state

77   level players in 20-m sprint, AFL agility, VJ, and 20-m MSFT (22, 23). Additionally, the

78   Athletic Abilities Assessment (AAA) has been used to assess functional movement skills of

79   players with the purpose of classification into talent pathway or senior elite levels, with higher

80   level players performing better in the AAA compare to lower level players (15, 29-31).

81   Furthermore, the AAA has shown moderate-to-large effects between elite AFL starters and

82   non-starters, with starters achieving higher overall tests scores than non-starters (12). However,

83   discrepancies exist between studies reporting the capacity of physical fitness and movement

84   tests to differentiate players across the AFL participation pathway; only the 20-m sprint, VJ,

85   and 20-m MSFT measures reported for Local U10 to U14 levels (13, 14, 16). Understanding

86   how players' physical fitness and movement fluctuates across the entire AFL participation

87   pathway levels may allow more informed decision-making by coaches/selectors on short- and

88   long-term player selection and development priorities.

89   The primary aim of this study was to establish physical fitness and movement ability profiles

90   of developing players at each level of the AFL participation pathway. A secondary aim was to

91   determine the extent to which these profiles could be used to classify players into their

92   corresponding pathway level. Additionally, we sought to establish whether specific physical

93   fitness and movement ability tests were more accurate at identifying players within a given

94   AFL participation pathway level than physical fitness and movement ability tests.

95

96   **METHODS**

97   *Experimental Approach to the Problem*

98   The AFL Draft Combine test battery is used nationally to assess the physical fitness

99   characteristics of players, with AAA score previously reported used to differentiate between

100   higher and lower level players (12, 15, 29-31). This study was a cross-sectional analysis of the

101   male AFL participation pathway between 2016 and 2018 seasons, with each player assessed at

102   one physical fitness testing session.

103   *Subjects*

104   All players (n = 293, age range: 10.9 – 19.1 years) were recruited from teams across multiple

105   competitions and age groups within the AFL participation pathway. Seven AFL participation

106   pathway levels were identified for analysis (Figure 1); four local participation pathway levels

107   (Local U12, Local U14, Local U16, and Local U18), and three talent pathway levels (National

108   U16, State U18, National U18). Local participation pathway players were classified as those

109   participating in local, private school, or school sport academy competitions. Players were

110   further classified into the following groups based on their age; Local U12 (n = 50, age range:

111   10.9 – 12.9 years), Local U14 (n = 94, age range: 13.0 – 14.8 years), Local U16 (n = 29, age

112   range: 15.0 – 16.9 years), and Local U18 (n = 15, age range: 17.0 – 18.2 years) with age limits

113   determined by age grouping policies stipulated by the AFL (5). For example, players were

114   categorized by age based on the calendar year (January 1st to December 31st) of that competition

115   year (e.g., Local U12 player ≤12 years on January 1st). Players competing in talent pathway

116   levels during the testing year were classified as National U16 (n = 45, age range: 15.4 – 16.3

117   years), State U18 (n = 38, age range: 16.4 – 19.1 years), and National U18 (n = 22, age range:

118   15.9 – 16.7 years) according to the age level they competed. All players were recruited from

119   the same state, apart from players within the National U18 team who are selected from regions

120 across Australia. Ethical approval was obtained from the Victoria University Human Research

121 Ethics Committee, with informed consent provided by participants or their parent/guardian

122 prior to participating in this research.

123   ***Insert Figure 1 near here***

Procedures

125 Physical fitness testing of players across the AFL participation pathway was conducted

126 between September 2016 and April 2018. Physical tests were: 5-m, 10-m, and 20-m sprint (s),

127 VJ and running VJ (left and right) (cm), AFL planned agility test (s), 20-m MSFT (level

128 achieved), and the AAA (score), with all testing completed according to the standardized AFL

129 Draft Combine protocols outlined in Woods, Raynor, Bruce, McDonald and Collier (32).

130 Following the 2017 AFL season, the YOYO Intermittent Recovery (IR) 2 test replaced the 20-

131 m MSFT test in the official AFL Draft Combine testing battery. The YOYO IR1, IR2, and 20-

132 m MSFT are highly correlated (ICC: $0.81 - 0.95$, $p \leq 0.01$), as such the 20-m MSFT was

133 considered an appropriate surrogate measure of aerobic fitness and comparability to previous

134 research findings (24). The AAA protocol consisted of the following movements performed in

135 this specific order; overhead squat, lunge (left and right), push-up, chin-up, and single-leg

136 Romanian Deadlift (RDL) (left and right) (30). Physical testing sessions followed a 10 min

137 standardized warm-up inclusive of aerobic and dynamic activities (32). Anthropometric data

138 including height (m) and body mass (kg) were collected prior to testing, with the order of

139 physical fitness tests randomized within each group. The one exception to this condition related

140 to the 20-m MSFT, which in line with AFL Draft Combine testing protocols, was completed

141 last (23, 32).

142

Statistical analysis

144 Descriptive statistics were obtained for each of the 11 tests across the seven pathway levels.

145 To determine the extent to which test scores differed between each level, a multivariate analysis

146 of variance (MANOVA) was undertaken. All assumptions of the MANOVA were required to

147 be met for players to be included in this analysis, with players only included if they were tested

148 on all physical fitness and AAA movements (n = 154). Critical p-value for consideration of

149 differences was reduced to 0.005 via the Bonferonni correction given multiple comparisons.

150 Post-hoc comparisons between ability levels were undertaken using a Games-Howell test,

151 given that nine of the eleven tests failed the Levene's test of equality of variances. Cohen's

152 effect sizes (*d*) were also obtained for each comparison, with ≥0.2 described as trivial, ≥0.5 as

153 moderate, and ≥0.8 as large effects (4). The descriptive statistics and MANOVA were

154 undertaken using the IMB SPSS Statistics software V25 (Version 25.0, IBM Corporation,

155 USA).

156 To determine the extent to which players could be classified into their respective ability level

157 (n = 293), a classification tree was constructed using the IBM SPSS Statistics software V25

158 (Version 25.0, IBM Corporation, USA). To minimize overfitting, the minimum number of

159 cases in order for a node to develop was set to 10, while the maximum tree depth was set to 10.

160 A confusion matrix was outputted to determine the extent to which players from each level

161 were classified accurately. Ten-fold cross validation was undertaken, with overall classification

162 accuracy outputted for both training and cross-validated sets. Figures 2, 3, and Supplementary

163 Figure 1 were produced using the *ggplot2* package within the RStudio® statistical computing

164 software version 1.1.453 (RStudio, Boston, Massachusetts).

165

166

167   **RESULTS**

168   *Physical Fitness Testing*

169   Descriptive statistics and standardized differences in players' physical fitness tests and

170   movement ability are presented in Figures 2, 3, and 4. A gradual increase in physical fitness

171   for most tests occurs with each progression in local pathway levels (Local U12 to Local U18),

172   with test performance remaining homogenous across talent pathway levels (National U16 to

173   National U18) (Figure 2). Movement abilities were similar across all AFL participation levels

174   for all AAA exercises. The one exception of the State U18 players scoring higher on the

175   overhead squat and left lunge (Figure 3).

176   Comparison between AFL participation pathway levels indicated that the magnitude of the

177   difference between physical fitness and movement ability was level-dependent. For example,

178   smaller differences were evident between National U18 and State U18 (ES: -1.43 to 0.68),

179   compared to National U18 and Local U12 (ES: -4.24 to 4.23) (Figure 4). However, no

180   substantial differences between Local U12 and Local U14 for any physical fitness or movement

181   ability test were observed. The 20-m sprint was the only test that exhibited substantial

182   differences between Local U12 and Local U14s and all other AFL participation pathway levels

183   (ES: -4.24 to -1.91). No difference was evident for 5-m sprint time between the Local U12 and

184   Local U14s when compared to the other AFL participation levels, except for the Local U14

185   and National U18s (ES: -1.21). The Local U12s were slower compared to the National U18s

186   for 10-m sprint time (ES: -2.45), with no differences observed for any other level. Local U14s

187   showed slower 10-m sprint times compared to all other AFL participation levels except the

188   Local U16 (ES: -1.89 to -1.44).

189   The Local U12s showed large differences from all AFL participation pathway levels for the

190   AFL agility, VJ, running VJ (left and right), and 20-m MSFT (ES: -4.64 to 5.02) (Figure 4).

191 However, no differences were observed between Local U12 and Local U18s for the AFL agility

192 and running VJ (left), or Local U16s for 20-m MSFT. The Local U14 showed no differences

193 compared to other participation pathway levels (i.e., Local U12, Local U16, and Local U18)

194 for AFL agility, VJ, running VJ, or 20-m MSFT. However, compared to the talent pathway

195 levels (i.e., National U16, State U18, and National U18) the Local U14s test performance was

196 lower for these physical fitness tests (ES: -2.66 to 3.17).

197   ***Insert Figure 2 near here***

Athletic Ability Assessment

199 The MANOVA comparison of movement ability between AFL participation pathway levels

200 indicated that the State U18 level had higher squat scores than the Local U12, Local U14, and

201 National U16 (ES: 1.24 to 2.07) (Figure 4). State U18s also displayed higher lunge scores

202 (right) compared to Local U12 and Local U14 (ES: 1.33 to 2.18). These players also displayed

203 higher left lunge scores than Local U12, Local U14, Local U18, and National U16 levels (ES:

204 1.11 to 2.60). National U16 also showed higher left lunge scores compared to Local U14

205 players (ES: 0.80). Lower push-up and chin-up scores were observed between the Local U12

206 and Local U14s when compared to the State U18s, and State U18 and National U18s (ES: 1.38

207 to 2.38), with Local U14 also having lower chin-up scores (ES: 1.40) than National U16. Local

208 U14s also had lower single-leg RDL scores (right and left) compared to the National U16 and

209 State U18 levels (ES: 0.98 to 1.28).

210   ***Insert Figure 3 near here***

211   ***Insert Figure 4 near here***

212

213   ***Classification of Players by Fitness and Movement Ability***

214   The utility of the fitness test scores and AAA measures to classify players into respective age

215   groups and levels is shown in Supplementary Figure 1. It appears that 20-m, 5-m, AFL agility,

216   20-m MSFT, overhead squat, and running VJ (right) were the only tests identified within the

217   classification model. For example, Local U12 and U14 were mostly identified as having 20-m

218   sprint >3.31 sec, 20-m MSFT >9.2 shuttles, and AFL agility >9.82 sec. The National U16 and

219   State U18 were mostly classified if they had: 20-m sprint <3.31 sec, 5-m sprint >1.07 sec,

220   overhead squat score <6.5, AFL agility <9.19 sec. The State U18 and National U16 were

221   differentiated by running VJ (right), with more State U18 classified with a jump height >66.5

222   cm, and more National U16 classified with a jump height <66.5 cm. The confusion matrix

223   output derived from the training model is shown in Table 1. An overall classification accuracy

224   of 57% was derived. The National U16 level players were most accurately classified based on

225   the 11 tests (87%), whereas National U18 were the most difficult to classify (0%). A reduction

226   in model performance was evident under 10-fold cross-validation, with overall classification

227   accuracy reduced to 43%.

228   *****Insert Supplementary Figure 1 link near here*****

229   *****Insert Table 1 near here*****

230   **DISCUSSION**

231   Physical fitness and movement profile(s) gradually improved with each progression in

232   competition level within the local participation level, however no change was observed

233   between talent pathway levels (i.e., National U16, State U18, and National U18). Movement

234   ability of players across the entire AFL participation pathway remained homogenous, with the

235   exception of higher overhead squat and left lunge scores for the State U18s. The only physical

236 fitness and movement ability tests that contributed to the classification model were the 20-m,

237 5-m, AFL agility, 20-m MSFT, overhead squat, and running VJ (right). Furthermore, the model

238 accurately classified over half of the players into the correct AFL participation pathway levels

239 based on these physical fitness and movement ability tests. The National U16 players were the

240 easiest to classify, however no National U18 players were correctly classified based on these

241 tests. Once players enter the National U16s level of the talent pathway, physical fitness and

242 movement ability became less important in classifying players.

243 The largest within-level physical fitness tests performance variation was in the Local U12 and

244 U14 levels, with these levels different to most of the AFL participation levels on all tests.

245 Players within the Local U12 and Local U14s are not exposed to structured physical training

246 at the recommendation of the AFL match policy guidelines (5). Consequently, the larger

247 variation in performance within the Local U12 and U14s may be attributed to substantial

248 between-subject variations in biological maturity of players within this group. Comparisons

249 between physical fitness test performances and the Tanner stages of maturity in adolescent

250 male athletes indicates that the Tanner 5 stage of maturity occurs at 14.4 ± 0.9 years, with

251 Tanner 1 occurring at 11.4 ± 0.4 years and Tanner 2 at 11.9 ± 0.7 years (17). In junior soccer

252 (U13-U16s) the biological maturity of players was positively correlated with jump, sprint,

253 agility, and aerobic endurance performance across similar tests used in this study (20, 26). This

254 effect may explain the expected physical fitness and movement differences between the Local

255 U12, Local U14 and the older levels within the AFL participation pathway, as the younger

256 players may be in the early stages of physical development.

257 Given almost half of the players were not able to be accurately classified based solely on

258 physical fitness and movement ability, it appears that other factors are important in successful

259 junior football. This is not surprising, given it is well established that successful elite players

260 overcome a variety of organismic, environmental and task constraints (7, 25, 26). Organismic

261 constraints such as growth, maturity, and learning stages all influence a player's physical

262 fitness characteristics (7, 28). Environmental constraints include differences in game play, skill

263 level, game rules, and field sizes (7, 25). Task constraints are the game objectives, sporting

264 actions, and the physical fitness qualities needed for high-level match performance (7, 25, 26).

265 As such, the inclusion of skills testing (i.e., kicking and handball tests), and performance

266 measures such as decision making ability and match performance indicators (i.e., game

267 statistics and match activity profiles) may improve the accuracy of the model (8, 26). Once

268 selected into the AFL talent pathway, players' physical fitness characteristics and movement

269 ability becomes more homogenous, as the classification model identified the National U18s as

270 the most difficult to level to classify. The limited ability to differentiate players between older

271 levels of the AFL talent pathway may result from other factors such as skill level; whereas

272 younger and less skilled players may rely more on their physical fitness attributes in training

273 and matches. Analysis of skills between State U18 and Local U18 AFL players indicated the

274 State-level U18 players had greater skill execution (accuracy) in dominant and non-dominant

275 kicking and handballing tests (33). Furthermore, a review of physical maturity and soccer skills

276 from a relatively homogenous group of junior players indicated more biologically mature

277 players expressed higher skill levels that may have resulted in more hours of practice

278 experience (20). As such, as players transition through the AFL local participation and talent

279 pathways other factors such as skills, psychological, and sociocultural influences may affect

280 their selection into higher talent competitions (1, 18), more so than physical fitness and

281 movement ability.

282 The exclusion of physical fitness and movement tests from the classification model (i.e., 10-m

283 sprint, VJ, left running VJ, and AAA tests) suggests the limited importance these tests have in

284 AFL talent identification. This outcome supports previous assertions that VJ does not clearly

285   relate to elite career progression in National U18 players, or contribute markedly to a player's

286   chance of selection into higher levels of competition within the talent pathway (22, 23).

287   Similarly, movement assessments appear limited for talent identification within the AFL

288   participation pathway, as only the overhead squat score was included in the classification tree.

289   These results contradict previous reports which indicate AAA has moderate discriminant

290   validity between selected and non-selected State U18 players, as well as starters and non-

291   starters in elite AFL players. Specifically, overhead squat, lunge, and single-leg Romanian

292   deadlift (left) showed significant differences between selected and non-selected players (34,

293   35). The movements that form the AAA screening are considered foundational movements that

294   underpin sport-specific movements such as: lower body and trunk stability, and triple extension

295   patterns of the hip, knee, and ankle required from sprinting, jumping and change of direction

296   (30, 31). Unsurprisingly, the Local U12 and U14s performed lower on the AAA screening

297   which may be indicative of training restrictions imposed by the AFL match policy; a policy

298   that provides recommendations on training foci for local participation pathway levels that

299   include minimal-to-no focus on physical fitness training (i.e., strength and conditioning) (5).

300   Conversely, the talent pathway levels are provided with physical fitness training, which creates

301   a training age gap between local participation and talent pathway players (2, 7). Therefore, the

302   outcomes of this study quantify the gap in movement abilities between the local and talent

303   pathways, providing strength and conditioning practitioners within the talent pathway a

304   baseline for incorporating short-term programs that target foundational athletic movement

305   skills (12). Furthermore, differences in movement ability between elite and talent pathway

306   players in previous studies highlight the importance of developing movement ability for long-

307   term success (15, 29, 30). While the AAA screening may not contribute directly to the

308   classification of players in this study, the movement ability of players may be an underpinning

309 factor that influences of other performance factors such as technical skills (i.e., kicking and

310 tackling), and match activity profiles.

311 The classification model included AFL agility which contradicts earlier reports. The extent to

312 which the AFL agility test can clearly discriminate between AFL drafted and non-drafted

313 players', or between talent pathway levels has been reported as questionable (22). However,

314 AFL agility time was included in the classification tree and therefore may be useful for

315 selecting Local level players into the talent pathway but not for selection into elite competition.

316 Furthermore, the inclusion of the 20-m MSFT in this model also supports running endurance

317 tests for differentiating between playing standards and career progression in State U18 and

318 National U18 players (36). Linear analysis approaches may be constrained by a single function,

319 and therefore may not be able to adequately identify differing physical fitness and movement

320 ability patterns across multiple AFL participation pathway levels (23). A limitation of this

321 study was that some groups only had a small number of players as they did not meet all the

322 assumptions of the MANOVA analysis. Further work is required to consolidate these findings

323 with larger samples to clarify the relationships between physical fitness and movement ability

324 of players within the AFL pathways. However, non-linear approaches provide greater insight

325 for coaches and talent selectors as they account for the patterns of physical fitness and

326 movement ability differences across the AFL participation pathway.

327 This study characterized the physical fitness and movement profile(s) of developing players,

328 the extent in which they differ between AFL participation pathway levels, and the degree to

329 which they could classify players into specific pathway levels. All physical fitness and

330 movement ability tests were strongest at differentiating Local U12 and Local U14 from all AFL

331 participation pathway levels; however, differences were smaller for movement ability tests than

332 physical fitness tests. The classification model indicated the 20-m and 5-m sprint, AFL agility,

333   20-m MSFT, squat, and running VJ (right) produced the highest accuracy in classifying

334   players. National U16s were more accurately classified based on physical attributes, with the

335   National U18 least accurate. The inability of physical fitness and movement ability tests to

336   classify National U18 players highlights the need to seek more contextual information when

337   selecting players into this level. As such, a limitation of this study is the restriction of this

338   classification model to physical fitness and movement ability only. It is suggested future

339   research should investigate models that incorporate skill measures, psychological, and

340   sociocultural influences. Additionally, talent scouts and coaches should consider a combination

341   of physical fitness and movement ability with other skill, psychological and sociocultural

342   factors when selecting individual players into the AFL talent pathway.

343   **PRACTICAL APPLICATIONS**

344   Classifying players to specific AFL participation pathway levels using physical fitness and

345   movement ability scores allows coaches and talent selectors to identify over-performing or

346   under-performing players at a given level, thus highlighting players that may require further

347   investigation of other contextual information. For example, a 15-year-old who concurrently

348   competes in basketball and AFL may exhibit similar 5-m, AFL agility, and jump scores

349   compared to an 18-year-old that has specialized early in AFL. This 15-year-old and/or 18-year-

350   old could be flagged by talent selectors and coaches to investigate the players' sporting

351   backgrounds as they present with physical fitness and movement abilities that are above/below

352   their age level. Furthermore, strength and conditioning practitioners may identify players that

353   are under-performing in key physical fitness and/or movement abilities important for their

354   competition level. This would provide more informed and individualized strength and

355   conditioning programs for players at varying development stages within the same AFL

356   participation pathway level.

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466   **Table 1.** Confusion matrix for the classification-tree model outlined in Supplementary Figure

467   1. Rows indicate the observed classification of players into their correct AFL participation

468   pathway levels. Columns show the predicted classification of players based on their physical

469   fitness attributes and movement ability characteristics.

470   **Figure 1.** Schematic diagram of the AFL participation pathway outlining the competition

471   hierarchy and flow of players within the local participation and talent pathway levels. U: Under

472   **Figure 2.** Distribution of physical fitness attributes of players within each AFL participation

473   pathway levels included in the classification-tree model. U: Under

474   **Figure 3.** Distribution of movement ability characteristics of players within each AFL

475   participation pathway level included in the classification-tree model. U: Under

476   **Figure 4.** Multivariate analysis of variance (MANOVA) between AFL participation levels,

477   physical fitness and movement ability tests. Values are presented as the effect size (ES)

478   between levels, with * denoting a significant difference ($p \leq 0.005$) between levels. MSFT:

479   Multi-Stage Fitness Test, RDL: Romanian Deadlift, U: Under, VJ: Vertical Jump

480   **Supplementary Figure 1.** Classification-tree illustrating the percentage of players classified

481   into AFL participation pathway levels based on physical fitness tests and movement ability

482   parameters detailed above each node. Note, n = number of players classified at each level

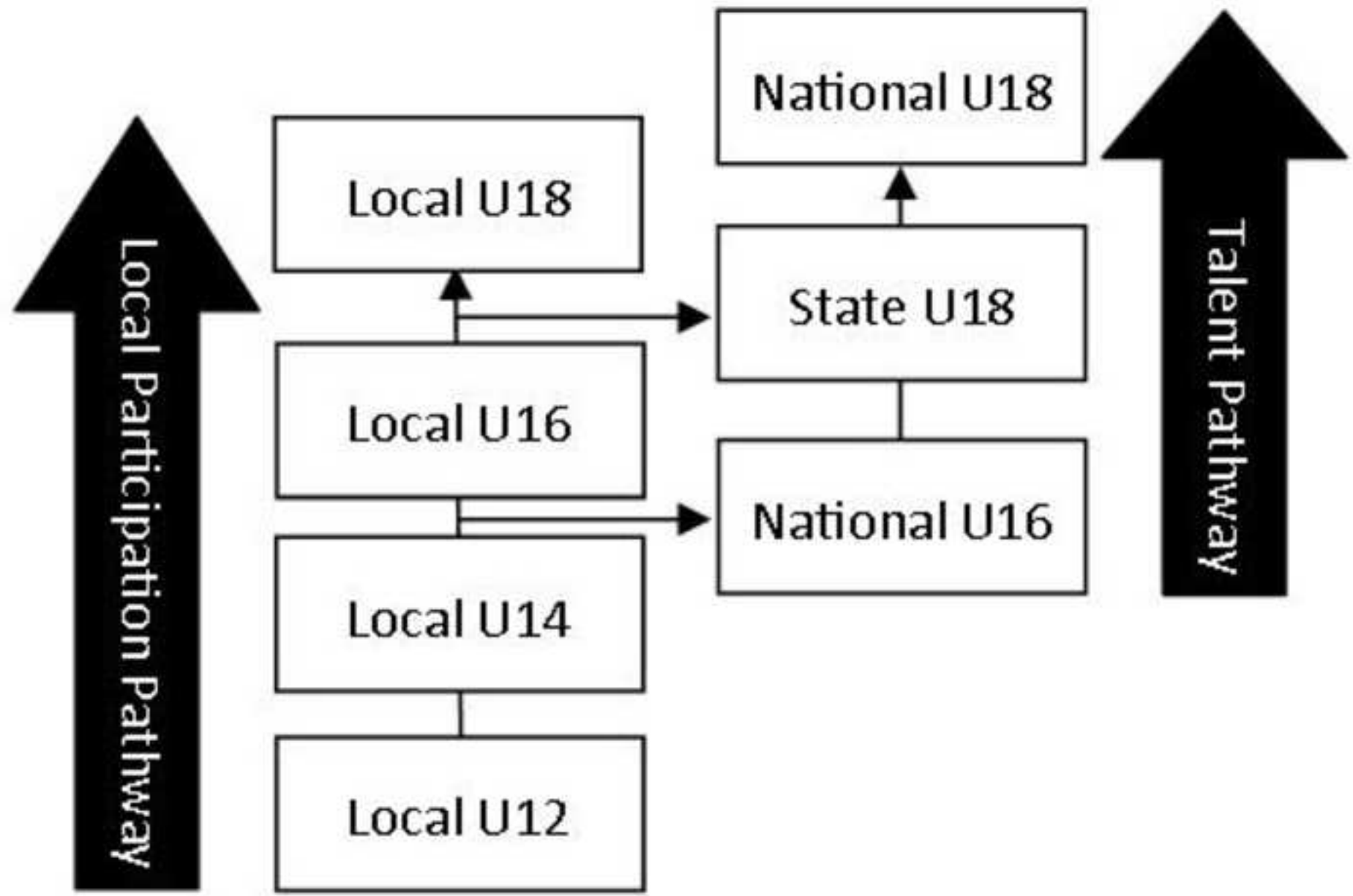483   within each node. RVJR: Running Vertical Jump (Right Leg), U: Under
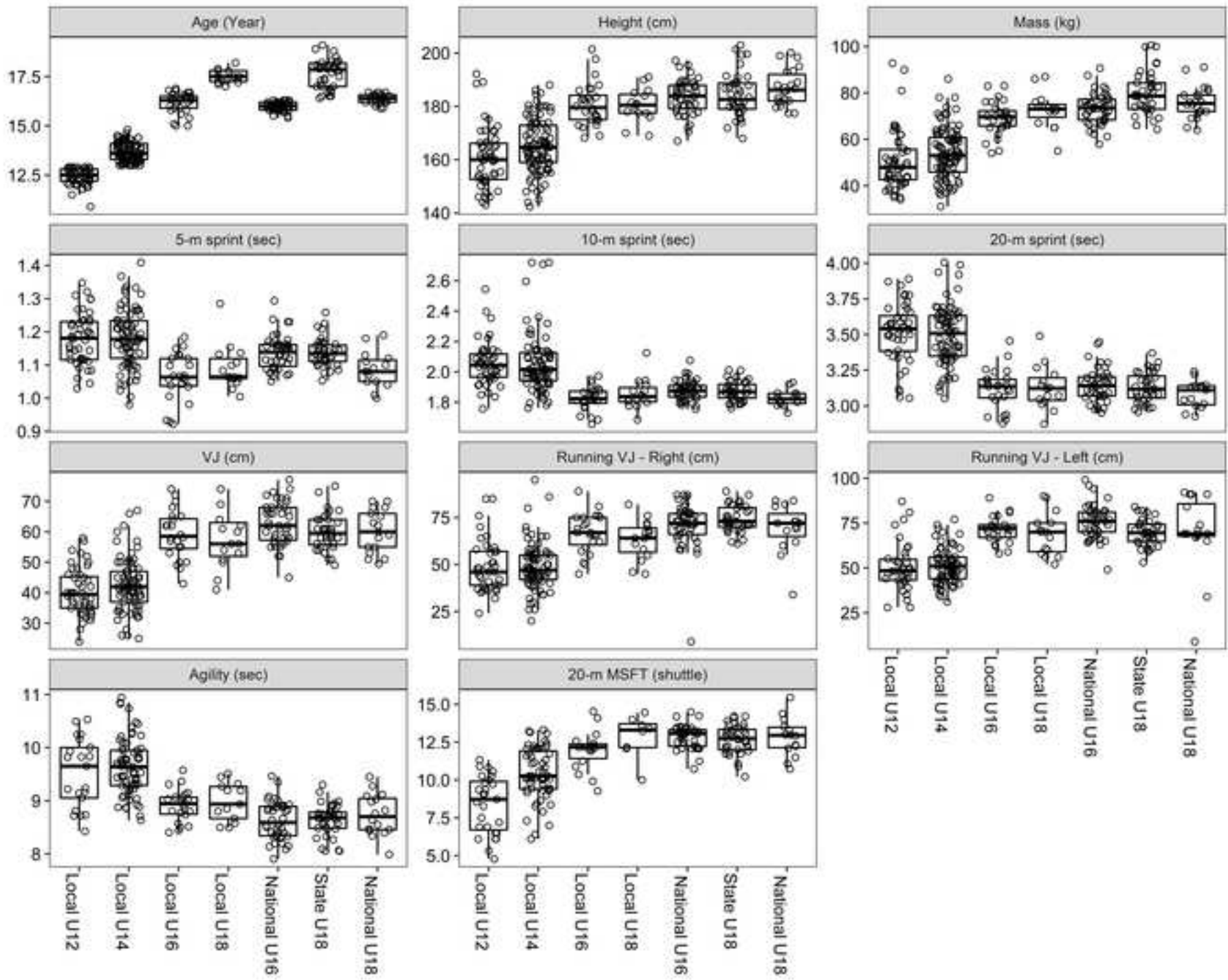

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Figure 1

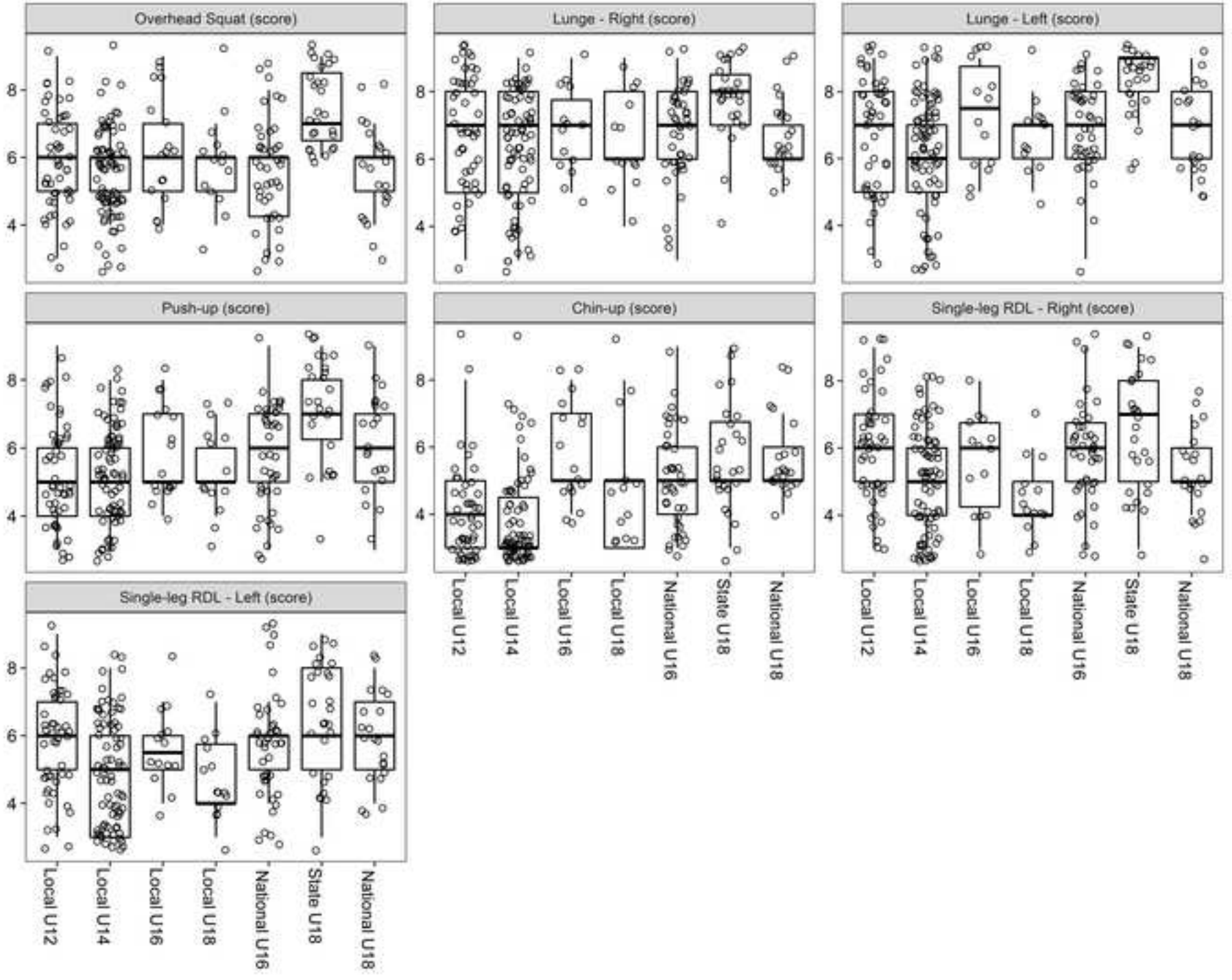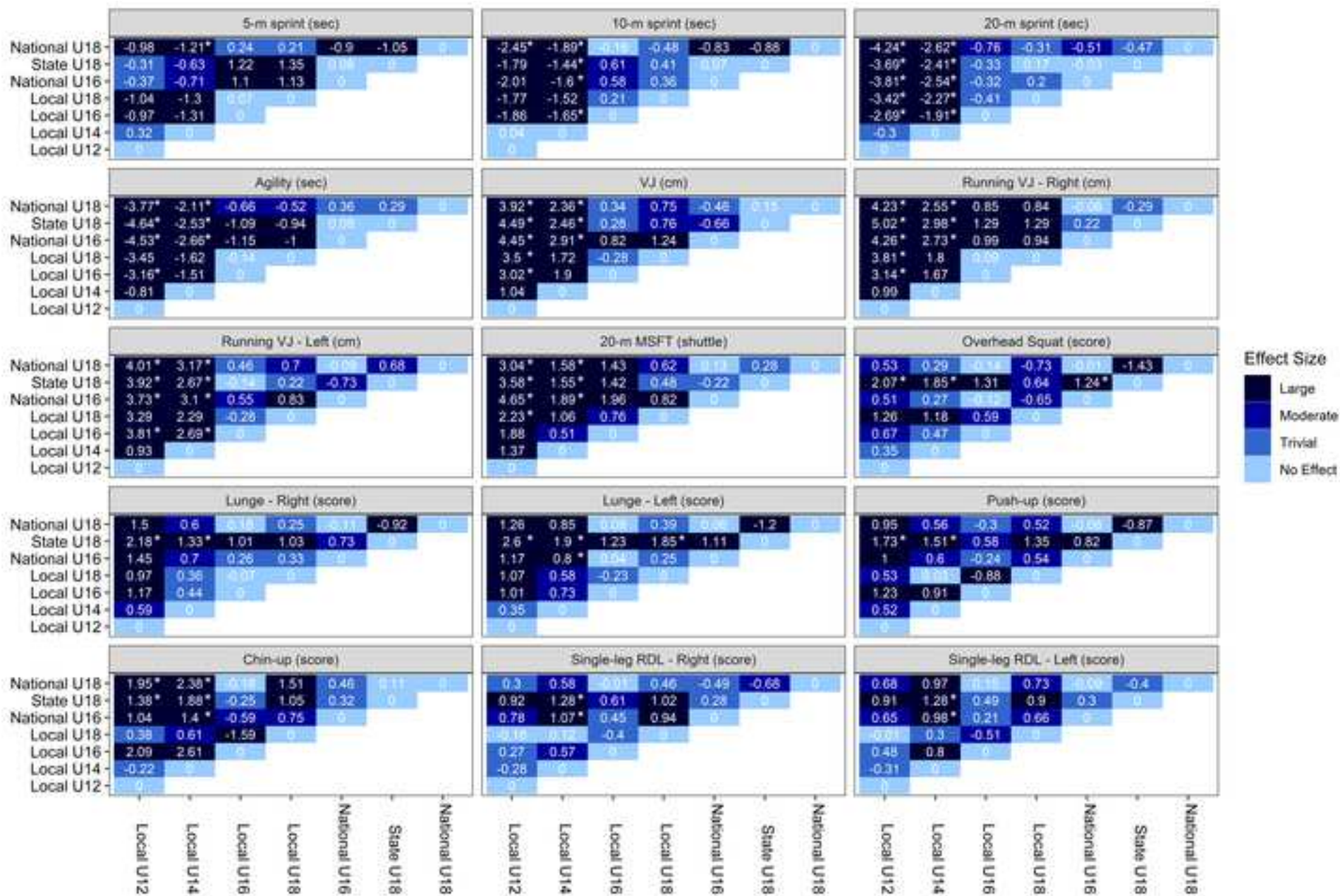

Figure 1

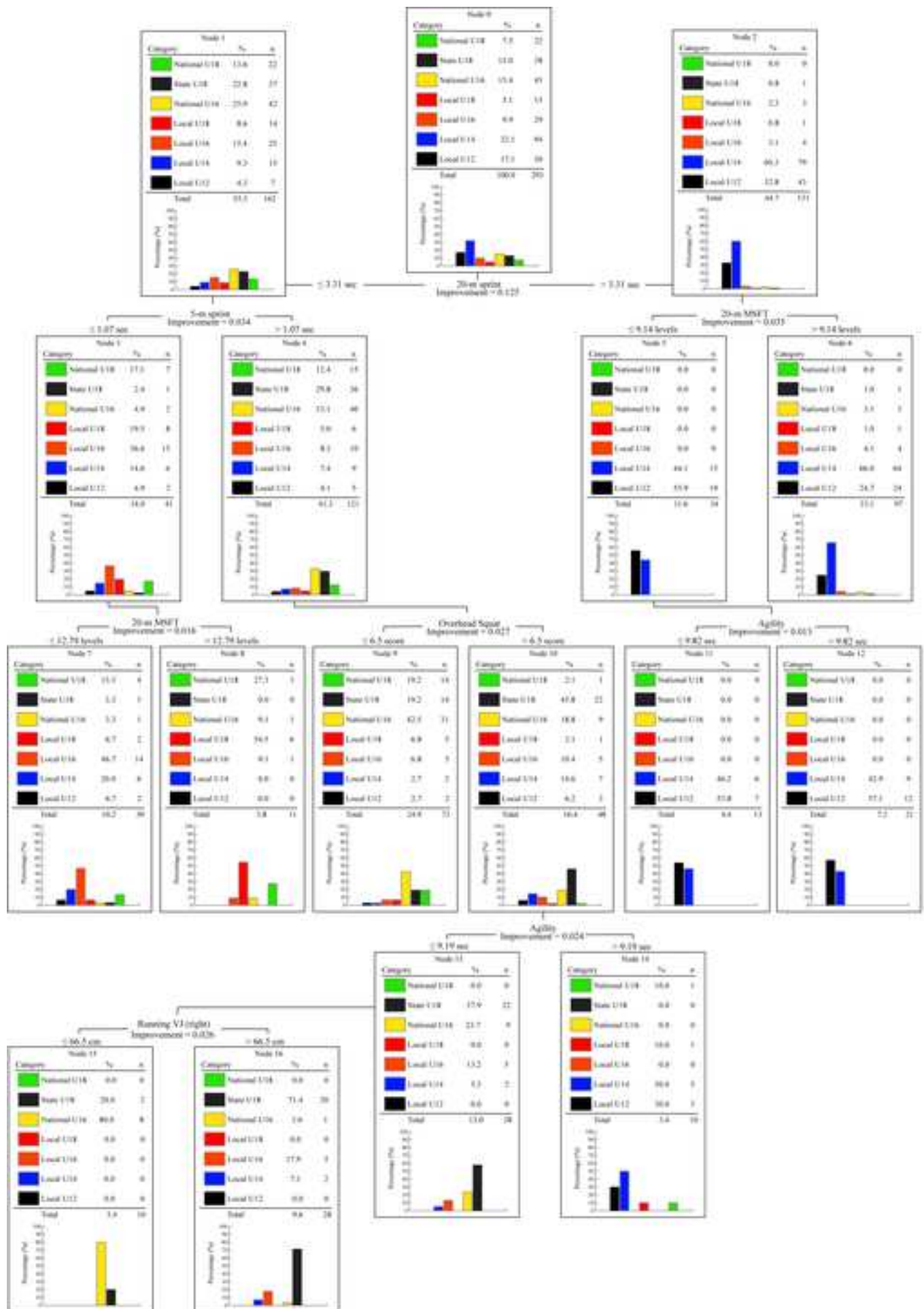Figure 2

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Table 1

Table 1. Confusion matrix for the classification tree model outlined in Supplementary Figure 1. Rows indicate the observed classification of players into their correct AFL participation pathway levels. Columns are show the predicted classification of players based on their physical fitness attributes and movement ability characteristics.

Observed	Local U12	Local U14	Local U16	Local U18	National U16	State U18	National U18	Classification Rate
Local U12	19	27	2	0	2	0	0	**38%**
Local U14	15	69	6	0	2	2	0	**73%**
Local U16	0	4	14	1	5	5	0	**48%**
Local U18	0	2	2	6	5	0	0	**40%**
National U16	0	3	1	1	39	1	0	**87%**
State U18	0	1	1	0	16	20	0	**53%**
National U18	0	1	4	3	14	0	0	**0.0%**
Overall Percentage	**12%**	**37%**	**10%**	**4%**	**28%**	**10%**	**0.0%**	**57%**