Title	Further development of the talent development environment questionnaire for sport
Author(s)	Chunxiao Li, Chee Keng John Wang, Do Young Pyun and Russell Martindale
Source	*Journal of Sports Sciences*, *33*(17), 1831-1843. http://dx.doi.org/10.1080/02640414.2015.1014828
Published by	Taylor & Francis (Routledge)

Further Development of the Talent Development Environment Questionnaire for Sport

Chunxiao Li
The Hong Kong Institute of Education
Nanyang Technological University
Chee Keng John Wang
Nanyang Technological University
Do Young Pyun
Nanyang Technological University
Russell Martindale
Edinburgh Napier University

Author Note

Chunxiao Li is with The Hong Kong Institute of Education. Chee Keng John Wang and Do Young Pyun are with Nanyang Technological University. Russell Martindale is with Edinburgh Napier University.

Correspondence concerning this manuscript should address Chunxiao Li, Department of Health and Physical Education, Hong Kong Institute of Education, 10 Lo Ping Road, Tai Po, New Territories, Hong Kong, Tel: +852 2948 8913, E-mail: cxlilee@gmail.com

We declare that there are no conflicts of interest in this study.

Keywords: *Talent development, questionnaire, validation, athlete*

Abstract

Given the significance of monitoring the critical environmental factors that facilitate athlete performance, this two-phase research aimed to validate and refine the revised Talent Development Environment Questionnaire (TDEQ). The TDEQ is a multidimensional self-report scale that assesses talented athletes' environmental experiences. Study 1 (the first phase) involved the examination of the revised TDEQ through an exploratory factor analysis (n = 363). This exploratory investigation identified a 28-item five-factor structure (i.e., TDEQ-5) with adequate internal consistency. Study 2 (the second phase) examined the factorial structure of the TDEQ-5, including convergent validity, discriminant validity, and group invariance (i.e., gender and sports type). The second phase was carried out with 496 talented athletes through the application of confirmatory factor analyses and multigroup invariance tests. The results supported the convergent validity, discriminant validity, and group invariance of the TDEQ-5. In conclusion, the TDEQ-5 with 25 items appears to be a reliable and valid scale for use in talent development environments.

Further Development of the Talent Development Environment Questionnaire for Sport

Introduction

There has been a growing interest in research examining the initiation or adoption of talent development (TD) programmes to achieve sporting excellence (Abbott & Collins, 2004; Baker & Schorer, 2010). TD is about providing the most appropriate learning environment to realise athletes' athletic potential (Williams & Reilly, 2000). This is important, because evidence has clearly shown that innate talents are not automatically transformed into word-class performers without appropriate TD experiences (Abbott, Collins, Sowerby, & Martindale, 2007; Gagné, 2004; Vaeyens, Lenoir, Williams, & Philippaerts, 2008). Rather, athletes need to go through a long-term developmental path to gain key attributes to realise their athletic potential (Ericsson, 2007). This implies that TD environments would benefit from being well planned, holistic and evidence based in order to successfully facilitate long term athlete progression (Martindale, Collins, & Daubney, 2005). The purpose of this research was to further develop and refine an instrument to help monitor the TD environment in an effective way.

Roles of the Talent Development Environment

It has been well documented that the TD environment affects athletes' development (Araújo & Davids, 2011; Henriksen, Stambulova, & Roessler, 2010a, 2010b; Martindale et al., 2010). From a developmental psychology perspective, the acquisition of expertise involves the process of interaction between the learner and the environment (Barab & Plucker, 2002; Bronfenbrenner, 2005). Parallel to this, sport expertise is acquired through successful adaptation of numerous environmental constraints or factors while gaining key sporting attributes during training and

competitions (Davids & Baker, 2007; Phillips, Davids, Renshaw, & Portus, 2010). Importantly, both researchers and practitioners acknowledge that key factors within TD environments are a controllable part in the course of developing athletes (Martindale, Collins, & Abraham, 2007). This highlights that rather than focusing merely on intrapersonal factors such as athletes' physical traits, key TD environmental factors should be identified and enhanced to effectively nurture talented athletes over the long term (Bailey et al., 2011).

Talent Development Environment Questionnaire

Given the significance of the environmental factors in TD, the 'Talent Development Environment Questionnaire' (TDEQ) was recently developed by Martindale and his colleagues (2010) to help facilitate evidence-based practice. The TDEQ was designed from a generic (non-domain-specific) and holistic (non-stage-based) perspective. In other words, this scale was not devised for measuring the environmental factors of a specific sport or developmental stage (cf., Martindale et al., 2010). The factor structure of the TDEQ was initially examined through an exploratory factor analysis using 590 talented adolescent athletes (Martindale et al., 2010). The analysis yielded a 59-item seven-factor structure with factor loadings ranging from .29 to .65. These seven factors were (a) long-term development focus (24 items, $\alpha = .98$), (b) quality preparation (five items, $\alpha = .62$), (c) communication (seven items, $\alpha = .91$), (d) understanding the athlete (four items, $\alpha = .73$), (e) support network (eight items, $\alpha = .90$), (f) challenging and supportive environment (four items, $\alpha = .62$), and (g) long-term development fundamentals (seven items, $\alpha = .88$). Furthermore, additional support for ecological validity of the TDEQ was provided (Martindale, Collins, Douglas, & Whike, 2013), indicating that this scale could be confidently applied in real sport settings.

Issues of the TDEQ

While the TDEQ can provide practitioners, such as coaches and administrators an evidence-based approach to help develop talented athletes, there are several issues with regards to this scale. First, there are 24 items in long-term development focus. This factor unfortunately contains too many items to assess one domain of interest only so as to increases the burden of administration of the scale by overloading survey respondents (Hatcher, 1994). Another deficiency is low internal reliability in the challenging and supportive environment subscale ($\alpha = .62$). More importantly, this factor is conceptually overlapped with support network as both factors concern providing support to athletes. In an effort to address the limitations, Wang and his colleagues (2011) revised the TDEQ by retaining only five representative items in long-term development focus and removing the challenging and supportive environment subscale. The item statements in this removed factor were mainly related to support network and long-term development (e.g., available support and de-emphasis of winning; Martindale et al., 2010). The remaining two factors (i.e., long-term development focus and support network) in the modified TDEQ still covered similar contents as measured by challenging and supportive environment. Thus, the removal of this factor would not affect the ecological validity of the TDEQ.

Although the aforementioned modifications were made by Wang et al. (2011) to refine the TDEQ, there were still several limitations of the revised scale. Firstly, low internal reliability was again found in quality preparation ($\alpha = .62$; Wang et al., 2011). Secondly, the factor structure of the revised TDEQ was tested in only one independent sample. As such, there is a need to enhance its generalisability and durability using other populations and to examine its factorial structure (Martindale et al., 2010; Wang et al., 2011) using more advanced analytic techniques such as

confirmatory factor analysis. This analytic technique allows researchers to verify the factor structure derived from exploratory factor analysis (Brown, 2006). Thirdly, it seems that some factors in the modified scale are still overlapped conceptually with each other. For example, both long-term development focus and long-term development fundamentals emphasise the provision of on-going opportunities to athletes. Lastly, it is of significance to recruit a heterogeneous sample to maximise data variations in a scale validation study (Clark & Watson, 1995). However, participants with different group memberships within a heterogeneous sample may interpret survey item contents differently. As such, a multigroup invariance test should be conducted to provide further psychometric evidence of the scale (Byrne, 2006).

Purpose of Study

In summary, although the revised TDEQ is a promising scale aimed at helping scholars and practitioners assess key TD environmental factors (Martindale et al., 2010, 2013; Wang et al., 2011), its psychometric properties need to be further examined. With further validation, the revised TDEQ could provide a more effective and efficient measurement tool to guide ongoing TD practice. As such, two studies were conducted with this purpose in mind. Study 1 was designed to test the factorial structure of the revised TDEQ using an exploratory factor analysis as it was a relatively new scale (Maneesriwongul & Dixon, 2004). Study 2 examined convergent validity, discriminate validity, and group invariance of the measures derived from Study 1.

Study 1

Method

An overview of research population

The participants of the current research were talented Singaporean athletes attending the Youth Sports Academy, schools, and National Sports Associations, where TD programmes have been operated. The Youth Sports Academy has been established to nurture youth athletes (13 to 18 years old) with athletic potential enrolled in mainstream schools. All youth athletes under the Youth Sports Academy must pass the selection trials for their specific sports before they can receive the high level of training and support. As the TD programmes under the Youth Sports Academy are only available in some schools, many other schools are running their own TD programmes (e.g., sports classes that emphasise developing talented athletes while supporting their academic programmes). Most National Sports Associations are also running TD programmes (e.g., identification and development of youth athletes through different national age-group squads). It is worthy to note that participants were from various organisations and sports, and identified by different groups of professionals (i.e., sport scientists, coaches, and/or physical education teachers). As such, varying methods and criteria were used to identify participants' sporting talent. However, because of the limitations of talent identification programmes (see Lidor, Côté, & Hackfort, 2009), it has been suggested that more attention should be paid to TD rather than talent identification (e.g., Bailey et al., 2010; Martindale et al., 2005).

In summary, all participants (N = 859) involved in this research were athletes identified with athletic potential using certain instruments developed by the Youth Sports Academy, schools, or National Sports Associations, and were being developed in TD programmes. As such, they were suitable for the purpose of this research. It is important to note that sporting success has been considered as the first priority for those participants from the Youth Sports Academy, National

Sports Associations, and sport school (n = 563, 65.54%). For the rest (n = 396, 34.46%), they were from five different schools and have been expected to achieve success in both sporting and academic fields just as a school tagline stated "learned champions with character".

Participants

Participants (N = 363; males = 204, females = 155, four participants did not indicate gender) were all talented athletes attending the TD programmes outlined above. Their mean age was 15.21 (SD = 2.18) years. They participated in various individual and team sports such as artistic gymnastics, badminton, basketball, bowling, and track and field. On average, they have trained in their sports for 5.43 years and 12.32 hours per week.

Measures

The revised TDEQ (Wang et al., 2011) was used to examine talented youth athletes' perceived TD environmental experiences (see Appendix). The revised scale had 36 items representing six factors: long-term development focus (five items, α = .79), quality preparation (five items, α = .62), communication (seven items, α = .85), understanding the athlete (four items, α = .75), support network (eight items, α = .83), and long-term development fundamentals (seven items, α = .77, Wang et al., 2011). The items were measured using a 6-point Likert scale, anchored with "strongly disagree" (1) and "strongly agree" (6).

Procedures

Ethical approval for the present research was granted by the university ethical review board. Before data collection, completed assent forms from all participants and consent forms from their parents/guardians were obtained. As the participants' official language is English, additional work for translation of the questionnaire

consisting of the revised TDEQ and demographic items (e.g., age, gender, and experience) was not necessary. The questionnaires were distributed to participants in quiet classrooms or meeting rooms under the supervision of coaches, school teachers, or the researchers. These supervisors provided support to the participants as necessary, to make sure they understood the item content. Participants were encouraged to respond to the questionnaire honestly, and it was emphasised that there were no right or wrong answers. It took approximately 10 minutes for them to complete the survey.

Data analyses

Data were analysed using SPSS 20.0. Before conducting the main analysis, preliminary analyses were conducted (i.e., missing data analysis, outliers cleaning, univariate normality, and internal reliability tests). Missing data were imputed using Expectation-Maximisation algorithm (Little, 1988). This imputation method is considered acceptable if a proportion of missing values is less than 5.0% (Hair, Black, Babin, & Anderson, 2010). Item *z*-scores beyond the range between -3.29 and 3.29 (99.9%) are considered as outliers and recoded (Larson & Farber, 2007). Item skewness and kurtosis values within the acceptable limit of ± 2.00 indicate univariate normal distribution in an item (Tabachnick & Fidell, 2013). Internal consistency tests were conducted on the two criteria: (a) an inter-item correlation between .20 and .70; and (b) a minimum corrected item-total correlation coefficient higher than .40 (Kidder & Judd, 1986).

In the main analysis, an exploratory factor analysis was conducted to examine the factorial structure of the revised TDEQ. Regarding the sample size, a subject to item ratio of at least 10 to 1 was deemed adequate (Gorsuch, 1983), meaning that the current sample size (i.e., $N = 363$) satisfied the requirement. In

addition, Kaiser-Myer-Olkin and Bartlett's test of sphericity were used to determine sampling adequacy. A Kaiser-Myer-Olkin value higher than .50 and a significant *p* value of Barteltt's test of sphericity support sampling adequacy. A principal component analysis was applied to extract a minimum number of factors that account for the maximum portion of the total variance explained by the data (Hair et al., 2010). A direct oblimin rotation was carried out as moderate correlations between the factors were observed (Martindale et al., 2010; Wang et al., 2011).

The criteria for the determination of the number of factors to be retained were the scree test, the magnitude of the eigenvalue (≥ 1.0), a preference for simple/clean structures over complex ones, and the TD literature (Cattell, 1966; Costello & Osborne, 2005; Kaiser, 1960). All these criteria were considered because no single technique has been shown to be adequate to determine the number of factors (Fabrigar, Wegener, MacCallum, & Strahan, 1999). Items or factors were excluded if the following conditions were met: (a) an item with a communality less than .40; (b) an item with a factor loading less than .40; (c) a factor with fewer than three items; and (d) cross-loading, namely an item that loaded at .32 or higher on more than one factor (Costello & Osborne, 2005; Hair et al., 2010).

Results

Preliminary analyses

Several missing values were imputed through Expectation-Maximisation algorithm due to a small proportion of missing values (0.5% to 2.0%; Little, 1988). All standardised item scores were within the normal range (z = -3.26 to 1.91), indicating that there were no outliers. All items were also univariate normally distributed (skewness = -0.72 to 0.10, kurtosis = -0.97 to 0.10). All inter-item correlations fell within the .20 to .70 range with an exception that the correlation between QP2 and

QP5 in quality preparation was .18. In addition, all corrected item-total correlations ranged from .41 to .72 except item QP5, which was below the benchmark value of .40 (.37). Taken together, item QP5 was removed from the item pool at this stage.

Factorial structure

The use of exploratory factor analysis was supported by the value of Kaiser-Myer-Olkin (.94) and the result of Bartlett's test of sphericity ($p < .001$). The remaining 35-item TDEQ was subjected to exploratory factor analysis. A six-factor structure accounting for 55.37% of the total variance was identified. The eigenvalues ranged from 1.04 to 11.21.

A total of seven items (i.e., LTfun2, LTfun3, COM3, COM7, QP1, SN7, and SN8) were removed based on the predetermined criteria (see Table 1). First, all the original items in long-term development focus were retained with a new item (LTfun1) loading on this factor. Second, two items (LTfun2 and LTfun3) in long-term development fundamentals were removed as they formed a new factor with only two items by themselves. The remaining four items in long-term development fundamentals (LTfun4, LTfun5, LTfun6, and LTfun7) together with item COM1 in communication formed a factor, which was named as alignment of expectations. Third, two items (COM3 and COM7) in communication were removed due to a cross-loading and a low factor loading, respectively. Fourth, items in quality preparation and understanding the athlete merged as one factor, which was named as holistic quality preparation. Lastly, two items (SN7 and SN8) from support network were removed due to cross-loadings.

****Table 1 near here****

After removing the seven items, no items with cross-loadings were found. Factor loadings and communities of the remaining 28 items ranged from .45 to .82 and from .40 to .68, respectively. This solution led to a five-factor structure (hereafter TDEQ-5) with acceptable internal reliability: long-term development focus (six items, $\alpha = .86$), holistic quality preparation (seven items, $\alpha = .79$), support network (six items, $\alpha = .81$), communication (four items, $\alpha = .79$), and alignment of expectations (five items, $\alpha = .80$). All these five factors were mildly to moderately correlated ($r = .19$ to $.66$, ps $< .01$) with an exception that the relationship between holistic quality preparation and support network was not significant ($r = .08$, $p > .05$).

Study 2

Methods

Participants

Another independent sample ($N = 496$; males = 235, females = 261) from the same research population were recruited. They were talented athletes with a mean age of 14.18 ($SD = 0.99$) years. They participated in 22 different individual and team sports such as archery, basketball, football, sailing, softball, table tennis, and volleyball (individual sports = 326, team sports = 170). On average, they have trained in their sports for 4.87 years and 10.73 hours per week.

Measures and procedures

The 28-item TDEQ-5 found in Study 1 (see Appendix) and questions measuring demographic information were used. The same data collection procedures used in Study 1 were followed.

Data analyses

The data were preliminarily analysed through SPSS 20.0 by following the same procedure in Study 1. Confirmatory factor analysis was then conducted to test the

psychometric properties of the TDEQ-5 using EQS 6.1 (Bentler & Wu, 2002). Specifically, the whole data set was split into two by random selection of approximately 50% of all cases: Sample 1 (n = 250) was used as a calibration sample and Sample 2 (n = 246) was used as a validation sample. The robust maximum likelihood estimation procedure (SBχ^2) is used (Chou & Bentler, 1995) if the data are not multivariate normally distributed (Mardia, 1970; Satorra & Bentler, 1994). Multiple fit indices were used to assess the global model fit: SBχ^2 to degree of freedom ratio (SBχ^2/df), comparative fit index (CFI), root mean squared error of approximation (RMSEA) with 90% confidence interval (90% CI), and standardised root mean squared residual (SRMR). A value of SBχ^2/df smaller than 3.0 indicates good fit (Kline, 2005). Traditional cut-off values (i.e., CFI $\geq$ .90, RMSEA $\leq$ .08, SRMR $\leq$ .08) were applied as indicators of acceptable fit, and higher cut-off criteria (i.e., CFI $\geq$ .95, RMSEA $\leq$ .06, SRMR $\leq$ .08) were adopted as evidence of good fit (Hu & Bentler, 1999; Marsh, Hau, & Wen, 2004).

Following the global model fit tests, we examined the internal model fit of the TDEQ-5 (i.e., internal reliability, convergent validity, and discriminant validity). Composite reliability (CR) values of .70 or above and average variance extracted (AVE) values higher than .50 indicate adequate reliability (Fornell & Larcker, 1981; Hair et al., 2010; Raykov, 1998). Factor loading estimates provide an indication of the item level of convergent validity, which should be higher than .50 and ideally greater than .707 (Fornell & Larcker, 1981; Hair et al., 2010). Discriminant validity is considered robust when the confidence interval of estimated correlations between the two latent factors never includes 1.00 (Anderson & Gerbing, 1988).

As both overall and internal model fit tests are unable to provide information about reasons of model misfit, standardised residuals and modification indices were

used to identify focal areas of ill fit (Brown, 2006). Standardised residuals range between – 2.58 and + 2.58 are deemed appropriate (Byrne, 1998). As the modification index is sensitive to sample size, the standardised expected parameter change was applied in tandem with the index to determine if it is necessary to re-specify the model (Brown, 2006). In addition to taking references to the standardised residual, modification index, and expected parameter change, model re-specification was made only when there was a compelling substantive theory to support it (Jöreskog, 1993).

Finally, measurement invariance of the scale across gender (males *vs.* females) and sports type (individual sports *vs.* team sports) was tested using the whole data. Three aspects of measurement invariance (i.e., configural, metric, and scalar variance) were evaluated (cf., Byrne, 2006). For model comparisons in multigroup invariance tests, the SBχ^2 different test is often applied. However, as the value of the SB$\Delta\chi^2$ test is very sensitive to sample size, another two criteria were also used: (a) if the multigroup model shows an adequate fit to the model, and (b) if a change of CFI value between two models (ΔCFI) is smaller than .01, suggesting a non-significant difference between the models (Byrne, 2006).

Results

Preliminary analysis

The missing data (0.2% to 2.4%) were imputed using Expectation-Maximisation algorithm (Little, 1988). No outliers in the data set were identified, and all items were univariate normally distributed. However, it was found that one item (LTfoc1) in long-term development focus was detrimental (i.e., negatively affected the internal reliability of long-term development focus) and had low corrected item-total correlation (.23). This item was therefore removed from the 28-item scale.

The first confirmatory factor analysis using Sample 1

The value of normalised estimate in Sample 1 (n = 250; male = 119, female = 131) was 17.81, indicating the data were not multivariate normally distributed (Bentler & Wu, 2002). As such, the remaining 27-item TDEQ-5 was subjected to confirmatory factor analysis using SBχ^2. The data showed adequate fit to the model: SB$\chi^2(314)$ = 493.00, SBχ^2/df = 1.57, CFI = .931, SRMR = .070, RMSEA = .048, 90% CI (0.040, 0.056). Table 2 presents the results of CR, AVE, and latent factor correlation matrix with 95% CI. All five factors had CR values higher than .70 (.83 to .87), and three factors had AVE values greater than .50 (.50 to .55). However, AVE values for holistic quality preparation (.49) and support network (.47) were slightly below the recommended cut-off. All item factor loadings were higher than .50 (.60 to .81), and 14 factor loadings were greater than .707, indicating adequate convergent validity. Discriminant validity of the scale was also supported as the latent factor correlations ranged from .18 to .82 with none of its 95% CI correlation coefficients exceeded 1.00.

****Table 2 near here****

All standardised residuals did not exceed ±0.22. The relatively large modification index (χ^2 = 48.11, expected parameter change = 0.89) of item SN4 suggested that the model could be re-specified. It was also found that item SN4 (“My training programmes are developed specifically to my needs”) described more about training programmes and individual development rather than support network. The modification indices also indicated that item SN5 (“My coaches ensure that my school/university/college understand about me and my training/competitions”) cross-

loaded on both long-term development focus and communication (χ^2 = 35.10/27.48, expected parameter change = 1.00/.82). Thus, items SN4 and SN5 were removed from the 27-item measurement model. The follow-up inspection of the modification indices and values of expected parameter change while considering TD literature showed that further specification of the model was not necessary.

The second confirmatory factor analysis using Sample 2

For validation of the remaining 25-item TDEQ-5, another confirmatory factor analysis using Sample 2 (n = 246; male = 116, female =130) was conducted. The SB$\chi^2$was used again (normalised estimate = 15.62; Bentler & Wu, 2002), and the results showed good model fit, SBχ^2 (265) = 366.56, SBχ^2/df = 1.38, CFI = .958, SRMR = .055, RMSEA = .040, 90% CI (0.029, 0.049). As shown in Table 2, reliability of the factors was evidenced as their CR values were higher than .70 (.80 to .87) and three factors had AVE values greater than .50 (.54 to .62; see Table 2). However, AVE values of long-term development focus (.44) and holistic quality preparation (.47) were lower than .50. Adequate convergent validity was supported as all item factor loadings were higher than .50 (.59 to .85), and 14 of which had factor loadings higher than .707. Latent factor correlations ranged from .21 to .88, and none of its 95% CI correlation coefficients exceeded 1.00, thus supporting the discriminant validity of the scale. There were no focal areas in terms of the standardised residuals, modification indices, and values of expected parameter change. In summary, the re-specified measurement model derived from Sample 1 was validated with Sample 2. The TDEQ-5 model with 25 items had adequate global model fit, internal reliability, convergent validity, and discriminant validity.

Group invariance across gender and sports type

There were 235 male participants involving in 19 individual and team sports and 261 female participants attending 14 individual and team sports. The results of the invariance tests across gender are summarised in Table 3. There was no substantial difference between the baseline model and the metric invariance model ($SB\Delta\chi^2$ = 36.68, df = 20, p > .01; ΔCFI = -.003). The baseline model and the scalar invariance model differed significantly based on the results of the $SB\Delta\chi^2$ test ($SB\Delta\chi^2$ = 176.29, df = 45, p < .01). However, there was no difference in the CFI between the two models (ΔCFI = -.002). Because of the negligible value of ΔCFI and overall adequate fit, it was concluded that the measurement model of the TDEQ-5 was invariant across gender.

****Table 3 near here****

There were 326 participants involving in 14 individual sports and 170 athletes participated in eight team sports. A significant difference between the baseline model and the metric invariance model was found ($SB\Delta\chi^2$ = 54.68, df = 20, p < .01; see Table 3). Nonetheless, there was no difference in the CFI between the two models (ΔCFI = -.006). Regarding the scalar invariance, the $SB\Delta\chi^2$ test revealed a substantial difference between the baseline model and the scalar invariance model ($SB\Delta\chi^2$ = 143.98, df = 45, p < .01). However, there was no difference across the two models when the ΔCFI criterion was used (ΔCFI = -.008). In summary, the participants in individual and team sports interpreted item contents in the same way given the adequate model fit among all the models and the negligible values of ΔCFI.

Discussion

It is clear that being able to monitor key TD environmental features is important and useful for practitioners such as coaches and sport administrators. Any tool that can help facilitate timely, evidence-based formative feedback in TD is welcome. To this end, the current research examined the psychometric properties of the revised TDEQ. Using exploratory factor analysis, Study 1 provided a preliminary factor structure of the TDEQ-5. Study 2 examined the factor structure, convergent validity, discriminant validity, and group invariance of the TDEQ-5 through confirmatory factor analysis.

The exploratory factor analysis yielded a five-factor solution with 28 items, explaining a total of 55.37% of the variance. The variance is comparable to Martindale et al.'s (2010) study (i.e., 64%) given that the challenging and supportive network factor was not included in the TDEQ-5. Further, the proportion of explained variance by the TDEQ-5 is deemed adequate in social science research and practice (Hair et al., 2010). Although the revised six-factor TDEQ (Wang et al., 2011) was used in Study 1, the exploratory factor analysis revealed a five-factor structure because four items in understanding the athlete and three items in quality preparation were merged into one factor (named as holistic quality preparation). As all items in holistic quality preparation were reversely worded, it might be plausible that this new factor emerged as a result of the "method effect" (i.e., items with negative statements can produce a distinct factor; Marsh, 1986). On the other hand, conceptually it is more reasonable for these items to be in the same factor considering the item contents. All these items tap into preparing athletes both within (e.g., a clear training guideline and psychological training) and outside sports (e.g., caring athletes' well-being and paying attention to athletes' life outside training), representing a more holistic TD preparation programme. In an effort to support the

homogeneity of these items within the factor, the additional item analysis showed that all inter-item correlations (.26 to .45) and item-total correlations (.43 to .55) fell within the benchmark range. Thus, the merged factor was conceptually and empirically supported.

In addition to the slight change of the factor structure, eight out of the 36 items were removed from the revised TDEQ. This level of item reduction is relatively typical during the process of scale development using exploratory factor analysis (e.g., Arnold, Fletcher, & Daniels, 2013; Bartholomew, Ntoumanis, & Thøgersen-Ntoumani, 2010). Possible justifications of the item reduction are discussed as follows. Firstly, item QP5 was removed due to its low inter-item correlation and corrected item-total correlation. A closer examination of item QP5 ("I feel pressure from my mates in sport to do things differently from what my coaches are asking of me") reveals that this item focuses more on peer pressure and is different from the other items within the same factor that are more concerned with training. Secondly, items LTfun2 ("I am encouraged to participate in other sports and/or cross train") and LTfun3 ("I often have the opportunity to talk about how more experienced performers have handled the challenges I face") formed an independent factor. These two items highlight cross-training and dealing with challenges, while the other items in long-term development fundamentals are closely related to adjustment of goals or expectations (e.g., LTfun4, "My coaches make time to talk to my parents about me and what I am trying to achieve"; LTfun5, "The advice my parents give me fits well with the advice I get from my coaches"). Thirdly, item COM3 in communication was removed as it cross-loaded on long-term development focus. The wording of this item ("My coach often talks to me about the connections/overlap between different aspects of my training such as training ethos,

completion performance, physically, mentally, technically, and tactically") states the rationale for the round development. As such, this item is logically correlated with long-term development focus emphasising that all different aspects of skills should be developed through training programmes. In a similar vein, two items (SN7 and SN8) in support network were removed due to cross-loadings. Fourthly, item QP1 was dropped due to its low communality. The low communality could be due to its ambiguous contents ("I struggle to get good-quality competition experiences at the level I require"). It could be difficult for participants to understand what are the exact levels of competition experience they need. Lastly, item LTfun1 ("I would be given good opportunities even if I experienced a dip in performance") in long-term development fundamentals loaded on long-term development focus. The statement of this item is about giving athletes ongoing opportunities for training and competitions, which fits well with the concept of long-term development focus (i.e., affording development opportunities to facilitate long-term development; see Martindale et al., 2010).

While exploratory factor analysis led to a more "clean" factor structure of the investigated scale, the process still caused a few problems. Specifically, the removal of item QP5 may affect the content validity of the TDEQ-5 as none of the remaining items in Holistic Quality Preparation concerns peer pressure. Peer pressure or support has been found to influence TD (see Li, Wang, & Pyun, 2014). Similarly, removing item LTfun3 (i.e., the only one that examines the influence of more experienced athletes or role models) may also impose negative effect on the ecological validity of the TDEQ-5.

It should be noted that a reduced number of items did not affect internal reliability of the TDEQ-5 (α = .79 to .86), which was comparable to or even better

than the revised TDEQ (α = .62 to .85). Even though several items of the revised TDEQ were removed, the TDEQ-5 still represents the key features of effective TD environment such as long-term development methods and wide ranging support network (Li et al., 2014; Martindale et al., 2005; Martindale et al., 2013). As the factor structure of the revised TDEQ was reorganised into a five-factor solution, the interpretation of each factor should be correspondingly re-conceptualised where applicable. Based on the findings of this study and relevant literature (e.g., Li et al., 2014; Martindale et al., 2005), the five factors were reinterpreted and presented in Table 4. In summary, Study 1 yielded the 28-item TDEQ-5, providing initial evidence to Study 2.

****Table 4 near here****

Study 2 firstly examined the factor structure of the TDEQ-5 through confirmatory factor analysis. It was found that the measurement model had adequate global model fit, supporting the five-factor structure derived from Study 1. Two items (SN4 and SN5) in support network were removed in Study 2. The removal of item SN5 (“My coaches ensure that my school/university/college understand about me and my training/competitions”) could affect the content validity of the TDEQ-5. Even though item SN5 describes the different aspects of the TD environment (e.g., communication and support network), it was the only one that encapsulates providing school support for athletes. However, the removal of item SN4 (“My training programmes are developed specifically to my needs”) would not affect the content validity of the TDEQ-5 as there were still many left items concerning the provision of individualised developing programmes (e.g., “My progress and personal

performance is reviewed regularly on an individual basis" and "My training is specifically designed to help me develop effectively in the long term").

Study 2 also found that the scale had acceptable internal reliability and convergent validity. One exception was that holistic quality preparation had AVE values slightly below .50 in both samples (sample 1 = .49; sample 2 = .47). Because this problem emerged in both samples, the wording of the items within this factor might contribute to the issue. In other words, all seven items in the holistic quality preparation factor were written in the negative direction, which might affect participants' responses especially among young participants (Marsh, 1986; Swain, Weathers, & Niedrich, 2007). Some participants may not read these negatively worded items carefully, resulting in error responses (i.e., an individual selects an answer that is opposite to his/her perceptions). Despite of the issue, measurement invariance of the TDEQ-5 in gender and sports type was evaluated in Study 2. Group invariance of the scale was established at metric and scalar levels, which provided evidence that the items in the five factors were perceived in the same operational manner across the different groups (Byrne, 2006; Cheung & Rensvold, 2002).

Given the adequate psychometric properties of the 25-item TDEQ-5, several potential applications of this scale are discussed below. Compared with the (modified) TDEQ, the TDEQ-5 is a more parsimonious multiple-item scale that can be easily used for evaluating TD practice. Specifically, practitioners such as stakeholders, coaches, and sports scientists can use this scale to better understand the five key dimensions of the TD environment. The TDEQ-5 may be most valuable when it is used for monitoring individual development and tracking one's improvements. Further, the TDEQ-5 can potentially be used for many research purposes (Martindale et al., 2010). For example, researchers can employ this scale to

determine which environmental factors are more important in predicting athletes' sport performance and mental health.

Limitations and future research directions

This research has several limitations that should be accounted for while interpreting and applying the findings. Firstly, the participants were recruited from local schools so the current sample may limit the generalisability of the results. Replication studies using samples in other contexts are necessary to generalise the current findings. Secondly, a mixture of both positively and negatively worded items is necessary to avoid acquiescence response bias (Marsh, 1986; Swain et al., 2007). However, holistic quality preparation contained seven items which were all reversely worded, and its AVE value was found slightly below the cut-off criteria (.50). Thus, it could be important for researchers to remind participants to avoid careless responses to these items while administering the scale in future. Alternatively, some of these items can be rewritten into the opposite direction. Thirdly, given the big difference in the number of participants between the two groups (individual sports = 326; team sports = 170) used in group invariance tests across sports type, the results should be interpreted with caution (Brown, 2006). Fourthly, the removal of a few of the original items of the modified TDEQ (i.e., QP5, LTfun3, and SN5) may affect the ecological validity of the TDEQ-5. Future research needs to either consider revising these "bad" items or including new items measuring the contents with regards to peer influences, role models, and school support. Further, as shown in the Appendix, the 25-, 28-, or 36-item TDEQ is available to practitioners or researchers for future use (e.g., further examine the ecological validity of the TDEQ). Finally, even though the current research advanced the development of the TDEQ, future research should provide further psychometric evidence of the scale such as test-retest

reliability, concurrent validity, and criterion validity. Alternative evaluation methods such as item response theory (Wilson, 2005) may be useful to examine its psychometric properties.

In conclusion, the results of this research provide substantial support for the TDEQ-5. This research confirms the first-order five-factor structure of the scale. It also provides the first evidence for convergent validity, discriminant validity, and group invariance of the scale within the framework of confirmatory factor analysis.

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Appendix

Six- and Five-Factor Talent Development Environment Questionnaire Factors and Items

Item Content	Study 1 Coding	Study 2 Coding	Decision (When)
1. My coach emphasises the need for constant work on fundamental and basic skills.	LTfoc1	LTfoc1	Removed (Study 2, preliminary analysis)
2. My training is specifically designed to help me develop effectively in the long term.	LTfoc2	LTfoc2	Retained
3. My coach emphasises that what I do in training and competition is far more important than winning.	LTofc3	LTfoc3	Retained
4. I spend most of my time developing skills and attributes that my coach tells me I will need if I am to compete successfully at the top/professional level.	LTfoc4	LTfoc4	Retained
5. My coach allows me to learn through making my own mistakes.	LTfoc5	LTfoc5	Retained
6. I would be given good opportunities even if I experienced a dip in performance.	LTfun1	LTfoc6	Retained
7. I am encouraged to participate in other sports and/or cross train.	LTfun2		Removed (Study 1, EFA)
8. I often have the opportunity to talk about how more experienced performers have handled the challenges I face.	LTfun3		Removed (Study 1, EFA)
9. My coaches make time to talk to my parents about me and what I am trying to achieve.	LTfun4	AOE1	Retained for AOE (Study 1, EFA)
10. The advice my parents give me fits well with the advice I get from my coaches.	LTfun5	AOE2	Retained for AOE (Study 1, EFA)
11. My progress and personal performance is reviewed regularly on an individual basis.	LTfun6	AOE3	Retained for AOE (Study 1, EFA)
12. I am involved in most decisions about my sport development.	LTfun7	AOE4	Retained for AOE (Study 1, EFA)
13. I regularly set goals with my coach that are specific to my individual development.	COM1	AOE5	Retained for AOE (Study 1, EFA)

14. My coach and I regularly talk about things I need to do to progress to the top level in my sport (e.g. training ethos, competition performances, physically, mentally, technically, tactically).	COM2	COM2	Retained
15. My coach often talks to me about the connections/overlap between different aspects of my training (e.g. technical, tactical, physical, and mental development).	COM3		Removed (Study 1, EFA)
16. My coach and I talk about what current and/or past world-class performers did to be successful.	COM4	COM4	Retained
17. My coach and I often try to identify what my next big test will be before it happens.	COM5	COM5	Retained
18. My coach explains how my training and competition programme work together to help me develop.	COM6	COM6	Retained
19. Feedback I get from my coaches almost always relates directly to my goals.	COM7		Removed (Study 1, EFA)
20. My coach rarely talks to me about my well-being. (R)	UND1	HQP1	Retained for HQP (Study 1, EFA)
21. My coach doesn't appear to be that interested in my life outside of sport. (R)	UND2	HQP2	Retained for HQP (Study 1, EFA)
22. My coach rarely takes the time to talk to other coaches who work with me. (R)	UND3	HQP3	Retained for HQP (Study 1, EFA)
23. I don't get much help to develop my mental toughness in sport effectively.	UND4	HQP4	Retained for HQP (Study 1, EFA)
24. I struggle to get good-quality competition experiences at the level I require.	QP1		Removed (Study 1, EFA)
25. I am rarely encouraged to plan for how I would deal with things that might go wrong. (R)	QP2	HQP5	Retained for HQP (Study 1, EFA)
26. The guidelines in my sport regarding what I need to do to progress are not very clear. (R)	QP3	HQP6	Retained for HQP (Study 1, EFA)
27. I am not taught that much about how to balance training, competing, and recovery. (R)	QP4	HQP7	Retained for HQP (Study 1, EFA)

28. I feel pressure from my mates in sport to do things differently from what my coaches are asking of me.	QP5		Removed (Study 1, preliminary analyses)
29. Currently, I have access to a variety of different types of professionals to help my sports development (e.g. physiotherapist, sport psychologist, strength trainer, nutritionist, lifestyle advisor).	SN1	SN1	Retained
30. I can pop in to see my coach or other support staff whenever I need to (e.g. physiotherapist, psychologist, strength trainer, nutritionist, lifestyle advisor).	SN2	SN2	Retained
31. My coaches talk regularly to the other people who support me in my sport about what I am trying to achieve (e.g. physiotherapist, sport psychologist, nutritionist, strength and conditioning coach, lifestyle advisor).	SN3	SN3	Retained
32. My training programmes are developed specifically to my needs.	SN4	SN4	Removed (Study 2, 1st CFA)
33. My coaches ensure that my school/university/college understands about me and my training/competitions.	SN5	SN5	Removed (Study 2, 1st CFA)
34. Those who help me in my sport seem to be on the same wavelength as each other when it comes to what is best for me (e.g. coaches, physiotherapists, sport psychologists, strength trainers, nutritionists, lifestyle advisors).	SN6	SN6	Retained
35. My coaches and others who support me in sport are approachable (e.g. physiotherapist, sport psychologist, strength trainer, nutritionist, lifestyle advisor).	SN7		Removed (Study 1, EFA)
36. All the different aspects of my development are organised into a realistic timetable for me.	SN8		Removed (Study 1, EFA)

Note. LTfoc = Long-Term Development Focus, LTfun = Long-Term Development Fundamentals, COM = Communication, UND = Understanding the Athlete, QP = Quality Preparation, SN = Support Network, HQP = Holistic Quality Preparation, AOE = Alignment of Expectations; EFA = Exploratory Factor Analysis; (R) = reversely coded items.

Table 1

Factor Loadings and Communalities for the Five-Factor Talent Development Environment Questionnaire

Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Communality
LTfoc1	**.66**	.09	-.05	-.10	.06	.07	**.56**
LTfoc2	**.72**	.01	.18	.03	.02	.03	**.65**
LTfoc3	**.69**	.10	.05	.06	.09	.07	**.59**
LTfoc4	**.52**	.06	-.03	-.16	.16	.17	**.54**
LTfoc5	**.46**	.00	-.05	-.26	.28	.01	**.56**
LTfun1	**.49**	-.08	.09	-.03	.19	.31	**.60**
LTfun2	.21	-.10	-.04	-.01	-.01	**.78**	**.68**
LTfun3	.18	-.01	.08	-.21	.23	**.43**	**.57**
LTfun4	-.16	.11	.31	.07	**.65**	.17	**.68**
LTfun5	-.10	-.01	.21	.09	**.61**	.27	**.59**
LTfun6	.27	.03	.01	-.21	**.49**	.01	**.58**
LTfun7	.17	-.01	-.09	-.14	**.66**	-.04	**.58**
COM1	.17	.02	-.02	-.06	**.69**	-.12	**.60**
COM2	.09	.06	-.01	**-.62**	.24	-.02	**.61**
COM3	**.34**	.05	.07	**-.48**	.09	-.01	**.57**
COM4	-.07	-.01	.22	**-.54**	-.02	.25	**.51**
COM5	.01	-.02	.15	**-.55**	.25	.12	**.63**
COM6	.30	.02	.24	**-.49**	.09	.00	**.68**
COM7	.23	-.07	**.35**	-.22	.29	-.25	**.56**
UND1	-.04	**.67**	-.12	-.28	-.16	.18	**.56**
UND2	-.21	**.57**	.05	-.23	.15	.21	**.51**
UND3	-.10	**.61**	.04	-.19	.01	-.09	**.40**
UND4	.19	**.64**	.06	.09	.05	-.03	**.49**
QP1	-.02	**.51**	-.06	.31	.08	.02	**.34**
QP2	.02	**.63**	-.02	.07	.01	-.15	**.42**
QP3	.12	**.68**	-.05	.06	.09	-.11	**.52**
QP4	.10	**.69**	.06	.05	-.12	.07	**.50**
SN1	-.09	-.08	**.82**	-.05	-.06	-.13	**.60**
SN2	.01	.02	**.73**	.04	.05	.04	**.58**
SN3	-.08	-.03	**.64**	.00	.14	.17	**.54**
SN4	.27	.00	**.45**	-.24	.05	.00	**.57**
SN5	.11	.06	**.49**	-.09	.14	.21	**.55**
SN6	.17	.01	**.46**	-.11	.15	-.06	**.43**
SN7	**.36**	.17	**.42**	-.24	-.09	-.01	**.55**
SN8	**.39**	.06	**.46**	.11	-.04	.11	**.46**

Note. LTfoc = Long-Term Development Focus; LTfun = Long-Term Development Fundamentals; COM = Communication; UND = Understanding the Athlete; QP = Quality Preparation; SN = Support Network; Factor 1 = Long-Term Development Focus; Factor 2 = Holistic Quality Preparation; Factor 3 = Support Network; Factor 4 = Communication; Factor 5 = Alignment of Expectations.

Table 2

Reliability and Validity for the Five-Factor Talent Development Environment Questionnaire

	CR	AVE	1. (95% CI)	2. (95% CI)	3. (95% CI)	4. (95% CI)	5. (95% CI)
1. Long-Term Development Focus	.83/.80	.50/.44	–	.43** (.30, .57)	.52** (.42, .62)	.73** (.65, .82)	.74** (.66, .81)
2. Holistic Quality Preparation	.87/.86	.49/.47	.51** (.38, .64)	–	.21** (.08, .21)	.36** (.23, .50)	.35** (.21, .48)
3. Support Network	.84/.87	.47/.62	.56** (.48, .65)	.18* (.05, .32)	–	.78** (.72, .84)	.81** (.76, .86)
4. Communication	.83/.82	.55/.54	.80** (.73, .87)	.26** (.13, .39)	.75** (.69, .81)	–	.88** (.83, .93)
5. Alignment of Expectations	.83/.87	.50/.56	.78** (.71, .84)	. 26** (.14, .38)	.72** (.65, .78)	.82** (.76, .89)	–

Note. **$p < .01$, *$p < .05$. CR = Composite Reliability; AVE = Average Variance Extracted; CI = Confidence Interval. CR and AVE values for Sample 1 are presented on the left hand side, and the results for Sample 2 are presented on the right hand side; the latent factor correlations for Sample 1 are presented below the diagonal, and the correlations for Sample 2 are presented above the diagonal.

Table 3

Fit Indices for Multisample Gender (Male =235, Female = 261) and Sports Analyses (Individual Sports= 326, Team Sports = 170)

Model	SBχ^2 (*df*)	CFI	SRMR	RMSEA (90% CI)	Model comparison	SB$\Delta\chi^2$(Δdf)	ΔCFI
Gender							
Model 1: Baseline males	410.23 (265)	.942	.055	.048 (.039, .057)	–	–	–
Model 2: Baseline females	376.73 (265)	.953	.060	.040 (.030, .049)	–	–	–
Model 3: Configural invariance	787.19 (530)	.947	.058	.044 (.038, .051)	–	–	–
Model 4: Metric invariance	822.64 (550)	.944	.064	.045 (.038, .051)	3 *vs.* 4	36.68(20)	-.003
Model 5: Scalar invariance	931.72 (575)	.945	.067	.046 (.040, .052)	3 *vs.* 5	176.29(45)**	-.002
Sports Type							
Model 1: Baseline individual sports	397.32 (265)	.957	.057	.039 (.031, .047)	–	–	–
Model 2: Baseline team sports	372.31 (265)	.937	.059	.049 (.037, .060)	–	–	–
Model 3: Configural invariance	770.02 (530)	.950	.058	.043 (.036, .049)	–	–	–
Model 4: Metric invariance	820.32 (550)	.944	.068	.045 (.038, .051)	3 *vs.* 4	54.68(20)**	-.006
Model 5: Scalar invariance	892.84 (575)	.942	.069	.046 (.039, .051)	3 *vs.* 5	143.98(45)**	-.008

Note. **$p < .01$; SBχ^2 = Satorra-Bentler Scaled chi-square; *df* = degree of freedom; CFI = Comparative Fit Index; SRMR = Standardised Root Mean Squared Residual; RMSEA = Root Mean Square Error of Approximation; CI = Confidence Interval.

Table 4

Descriptions of Constructs of the Five-Factor Talent Development Environment Questionnaire

Factor	Descriptions
1. Long-Term Development	The extent to which developmental programmes are specifically designed to facilitate athletes' long-term success (e.g., fundamental training and rounded development, ongoing opportunities, and de-emphasis of winning).
2. Holistic Quality Preparation	The extent to which intervention programmes are prepared both inside and outside of sports settings (e.g., caring coach, clear guidance, mental preparation, and balanced life).
3. Support Network	The extent to which a coherent, approachable, and wide-ranging support network is available for the athlete in all areas (e.g., professionals, parents, coaches, and schools).
4. Communication	The extent to which the coach communicates effectively with the athlete in both formal and informal settings (e.g., development path, rationale for training, and feedback).
5. Alignment of Expectations	The extent to which goals for sport development are coherently set and aligned (e.g., goal setting, goal review, and individualised goals).

Adapted from Martindale, R. J. J., Collins, D., Wang, J. C. K., Michael, M., Lee, K. S., Sproule, J., & Westbury, T. (2010). Development of the Talent Development Environment Questionnaire for sport. *Journal of Sports Sciences, 28,* 1209-1221.