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Temporal dynamics of the quality of the coach-athlete relationship over one season among adolescent handball players: a latent class analysis approach

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ABSTRACT

Objective. The purpose of this study was to examine the temporal evolution of the quality of the coach-athlete relationship (CAR), in terms of athletes' perceptions of commitment, closeness, and complementarity, over a 1-season period. More precisely, the intra-individual temporal dynamic of the quality of the CAR was explored in three complementary ways: (1) mean change in the whole sample, (2) inter-individual differences between athletes, and (3) intra-individual stability and/or change of CAR profiles.

Method. Eighty handball players (*Age* = 16.15; 78% boys) involved in intensive training centres completed a measure of the quality of the CAR across three time points (beginning, middle, and ending of the season). Data were analysed using latent class growth and latent profile transition analyses. **Results.** Latent class growth analyses indicated that athletes' perceptions of closeness and complementarity linearly decrease – on average – over the season, whereas those of commitment decreases in a quadratic way (U-shape). In addition, results revealed three distinctive athletes' trajectories for closeness and complementarity, and four for commitment, suggesting inter-individual differences in the intra-individual evolution of the perceived quality of the CAR. Finally, latent profile transition analyses highlighted the existence of four distinct CAR profiles, and revealed that most athletes displayed the same profile over the season, but some of them changed their profile over time. **Conclusion.** As a whole, these results highlighted the dynamic aspect of athletes' perceived quality of the CAR, suggesting that this relationship is likely to evolve in different ways over a season in intensive training context.

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For the last twenty years, the coach-athlete relationship (CAR) has been the subject of many studies indicating that the way coach and athlete perceive, interact, and communicate with each other may have significant consequences on performance and well-being-related factors such as satisfaction and motivation (Jowett, 2017). Hence, establishing and maintaining a good CAR over time seems to be an essential element to produce high and stable performance as well as to foster athletes' and coaches' well-being.

However, although several researchers have suggested that CAR may evolve through time (e.g., Jowett & Cockerill, 2003), little is known about the temporal evolution of the CAR. The present study explored the temporal dynamic of the quality of the CAR over a one-season period, from the athlete's perspective.

The CAR has been defined by Jowett (2017) as a unique interpersonal situation in which coaches' and athletes' feelings, thoughts, and behaviours are interdependent and interconnected. More precisely, this relationship has been conceptualised through the 3+1Cs model which considers the quality of the CAR as the result of the combination of four dimensions: Closeness, commitment, complementarity, and co-orientation (Jowett & Poczwardowski, 2007). Closeness corresponds to the emotional aspects of the CAR and refers to the affective connection between coach and athlete, notably reflected by trust, mutual respect, and emotional support perceived in the dyad. Commitment is related to the cognitive characteristics of the relationship, and refers to the long-term intention of dyad's members to maintain their relationship over time, in order to achieve goals. Complementarity reflects the behavioural elements of the CAR, and could be characterised by the type of interaction adopted by the coach and the athlete, promoting a sense of teamwork, collaboration and cooperation. Finally, co-orientation reflects coaches and athletes' level of interdependence in terms of similarity and understanding concerning their views of closeness, commitment, and complementarity within their relationship (Jowett, 2017). Many studies have explored the theoretical propositions of the 3+1Cs model and revealed that the quality of the CAR – in terms of level of closeness, commitment, complementarity, and co-orientation between coaches and athletes – may have consequences for performance, as well as on numerous affective, interpersonal, and motivational processes (for a review, see Roux & Trouilloud, 2021). For instance, the quality of the CAR appeared positively related to well-being (e.g., Jowett et al., 2017a), group cohesion (e.g., Felton et al., 2021), and enjoyment during practice (e.g., Gardner et al., 2018), as well as negatively related to athletes' burnout (e.g., Isoard-Gautheur et al., 2016), and dropout (e.g., Gardner et al., 2017). Thus, the level of closeness, commitment, complementarity, and co-orientation within the CAR can be considered as a key element in an athlete's development (Jowett, 2017).

Because CAR is grounded within social context, it may be viewed as a dynamic process thought to change over time (Jowett & Poczwardowski, 2007). More precisely, its nature (and its characteristics) is expected to evolve over time in response to the dynamic quality of human cognitions, emotions, and behaviours shaped through the interactions of the relationship members (Jowett & Cockerill, 2003). For example, if a coach has high expectations toward their athlete at the beginning of the season, but the athlete does not fulfill those expectations, the coach may progressively be less enthusiastic about training and thus interact less frequently, give less support and feedback to the athlete (Sarrazin et al., 2005). In response, the athlete may feel less close to their coach, and therefore may perceive their relation in a less positive way than at the beginning of the season. Thus, the temporal patterning of CAR needs to be examined into research, particularly because relationships develop, dissolve, and go through various phases (Sandström et al., 2016). For example, a significant success or failure in an important competition can be an effective agent of change, potentially influencing several issues, including how athletes and coaches interact with each other in the future (e.g., Sagar et al., 2010). On this point, Antonini Philippe et al. (2011) underlined the "evolving nature" of the CAR. The

time spent together and the mutual understanding (e.g., through key events such as successes/failures) may result in changes in the roles of the athlete and coach and engage them in new forms of cooperation. Nevertheless, most previous studies examining the quality of the CAR used cross-sectional protocols that do not allow exploring temporal changes. The lack of longitudinal designs is one of the most cited limitations in the literature on the 3+1Cs model (e.g., Jowett et al., 2017). The exploration of the temporal evolution of the CAR quality could provide a more in-depth understanding of its consequences on athletes' development over time (Nicholls et al., 2017), as well as perspectives for coaches to improve the CAR quality (Roux & Trouilloud, 2021). Indeed, identifying and understanding the temporal evolution of athletes' perceptions of closeness, commitment, and complementarity could bring interesting feedback for coaches to adapt their relational strategies throughout the season (for a presentation of these strategies, see Rhind & Jowett, 2012).

However, to the best of our knowledge, only two studies explored the temporal evolution of the quality of the CAR (Gardner et al., 2018; Nicholls et al., 2017), and these have provided inconsistent results. Nicholls et al. (2017) suggested that young English soccer players' perceptions of the quality of CAR remained stable over a six-months period. In contrast, Gardner et al. (2018) indicated that young Australian high school students' perception of the quality of the CAR slightly decreased, on average, over a one-year period. In addition to these mixed results, some methodological and statistical concerns can be raised about these studies. Firstly, the data analysis strategy – bivariate correlations (Nicholls et al., 2017) and difference scores analyses (Gardner et al., 2018) – as well as the inclusion of two measurement points only, did not permit to explore non-linear variations (Chan, 2002). On this point, given the unpredictable nature of some events occurring in a season (e.g., injury), it may be assumed that the CAR quality does not systematically evolve in a linear way (Sandström et al., 2016). For example, it could be suggested that an athlete injured in the middle of the season will have fewer interactions with their coach, which could lead to a deterioration in the quality of CAR during this period. In contrast, more interactions with the coach when returning from injury could lead to a rebound in CAR quality at the end of the season, thus describing a non-linear trajectory in the evolution of athletes' perceptions of the quality of the CAR over time. Given these elements, we suggest that the quality of the CAR might develop in a non-linear way over a sport-season. Nevertheless, the observation of non-linear patterns requires a minimum of three measurement times. Over the past few years, growth models emerged as a viable alternative to correct several problems with traditional approaches, such as including partially missing data, complex non-linear trajectories, and multivariate growth processes (Curran et al., 2010). For those reasons, the present study used a three-wave design and growth models to explore temporal variation of the quality of the CAR. Furthermore, the variable-centered approach used in previous studies implies another limitation for the exploration of the evolution of the CAR: This kind of design does not allow to consider inter-individual differences in athletes' perception of the CAR (Laursen & Hoff, 2006). Yet, there may be distinct trajectories of athletes' perception of the CAR within the same sample. Consequently, a person-centered approach may be particularly interesting to identify specific longitudinal patterns of athletes' perceptions of the quality of the CAR. To the best of our knowledge, this person-centered approach has never been used to explore temporal changes in the quality of the CAR.

Based on the elements above, the main purpose of this study was to explore the temporal dynamic of the quality of the CAR – among adolescent athletes involved in intensive training centres – over a one-season period. Specifically, this study focused on the evolution of athletes' perceptions of closeness, commitment, and complementarity. A three-wave design was used in order to explore this dynamic through a person-centered approach, in three complementary ways.

The first objective was to observe the mean intra-individual change of the quality of the CAR in the whole sample. On this topic, although the CAR quality has been globally considered as a key element of athletes' development and well-being (e.g., Jowett, 2007), this phenomenon seems to be particularly important for adolescent athletes involved in intensive training centres. In fact, adolescence may be considered as a key period for athletes to "grow up to elite" (Sandström et al., 2016). More precisely, talented adolescent athletes are often likely to move far from home to join an intensive training centre (Sandström et al., 2016), where the coach becomes one of the people with whom the athletes interact most on a daily basis (Kuhlin et al., 2020). During this period a poor quality relationship with the coach may lead athletes to drop out (e.g., Gardner et al., 2017) whereas harmonious interactions between coach and athletes may help athletes to feel secure and overcome difficult moments (Sandström et al., 2016). In this perspective, the quality of the CAR appears as a crucial element in the athlete's sport and personal development during this period. Moreover, some studies suggested that the quality of the CAR is a particularly salient factor in contexts of intensive practice (Kuhlin et al., 2020). In particular, athletes involved in intensive training centres are subject to numerous physical (e.g., many training sessions), psychological (e.g., pressure to be constantly efficient) and social (e.g., coach's expectations) constraints (Martinet & Decret, 2015). More precisely, the high expectations and goals of coaches toward athletes in this context may contribute to the perception of a controlling and pressuring environment (Cece et al., 2019). Moreover, the high frequency of training in these centres generates many daily interactions between the coach and the athlete, and athletes are likely to be exposed on a regular basis to a controlling and constraining environment. Yet, several studies indicated that a constraining and pressuring environment (e.g., through athletes' perceptions of coaches' controlling behaviours) could lead to a deterioration of the CAR quality (e.g., Choi et al., 2013; Fouraki et al., 2020). In view of these elements, it could be considered that being confronted on a regular basis with high expectations and constraints from the coach could lead to athlete weariness, resulting in a progressive deterioration of the quality of the CAR over time. These elements led us to hypothesise that the perceptions of the CAR quality of athletes involved in intensive training centres were likely to decrease – on average – over the season. More specifically, because we previously suggested that the quality of the CAR might evolve in a non-linear way, the linear and quadratic trajectories of athletes' perceptions of closeness, complementarity, and commitment were examined.

The second objective was to explore potential inter-individual differences in the intra-individual dynamic of the quality of the CAR, in order to identify different classes of athletes sharing similar longitudinal patterns. On this point, previous studies highlighted the existence of inter-individual differences between athletes in their perceptions of the CAR quality. For example, Jowett et al. (2012) indicated that differences in athletes' personality traits (e.g., agreeableness, neuroticism) are likely to influence their perceptions of the CAR quality. These elements

suggest that there may exist inter-individual differences in athletes' perceptions of the evolution of the CAR quality. However, because no previous study investigated this topic among adolescent athletes involved in intensive training centres, no specific hypothesis was made concerning the number, the frequency, and the characteristics of those classes.

Finally, the third objective was to explore the issue of stability and/or change within the intra-individual dynamic of the quality of the CAR. Specifically, we investigated whether there were different athlete profiles at each measurement time in terms of perceptions of closeness, complementarity and commitment, and whether athletes moved from one profile to another over time. On this point, most studies on the 3+1Cs have explored the quality of the CAR either through a global indicator (e.g., Isoard-Gautheur et al., 2016) or by considering closeness, commitment, and complementarity as independent dimensions (e.g., Wekesser et al., 2021). Such approaches neglect the multidimensional nature of the CAR quality. The dimensions of closeness, commitment, and complementarity coexist within each CAR and should be considered as interconnected (Jowett & Ntoumanis, 2004). However, no previous study has explored the quality of the CAR considering athletes' profiles in terms of perceived closeness, commitment, and complementarity. The latent profile transition analyses (LPTAs) used in the present study allow to fill this gap by exploring (a) the multidimensional nature of the CAR quality – through athletes' profiles of athletes' perceived closeness, commitment, and complementarity – and (b) how athletes may change profiles over time. Because no previous study has been conducted on this issue in the literature, no specific hypothesis was made concerning the probabilities of athletes' changes from one profile to another over time.

Method

Participants and procedure

Eighty French adolescent handball players involved in intensive training centres (63 boys and 17 girls) who were aged from 15 to 17 years old ($Mage = 16.15$ years, $SD = 0.99$) voluntarily participated to this study. Intensive training centres correspond to structures that receive the best players in France during high school. The aim of these structures is to prepare and train athletes to subsequently join the national teams and become professional players. Athletes trained an average of 11.16 h a week and played at a regional (43%) or national (57%) level. Three measurement times were performed: At the beginning (November), middle (February), and end (May) of the season. Training centres managers were contacted in advance to get permission for the study. A written consent form was then given to all participants and their parents, indicating the purpose of the study and informing that their participation was voluntary and that they could withdraw from the study at any time. Athletes completed the questionnaire before a training session in a dedicated room. Athletes took about 15 min to complete the questionnaire. Institutional ethical approval was obtained from the Ethics Committee for Non-Interventional Studies of the first and third author's university.

Measures

The French version of the Coach-Athlete Relationship Questionnaire (CART-Q) (Jowett et al., 2017b) was used to assess athletes' perceptions of the quality of the CAR. The 11

items of the CART-Q measure the three dimensions of the CAR: Commitment (3 items; e.g., "I am committed to my coach"; $\omega > .88$ at all measurement times), closeness (4 items; e.g., "I like my coach"; $\omega > .86$), and complementarity (4 items; e.g., "When I am coached by my coach, I am ready to do my best"; $\omega > .78$). All CART-Q items were measured on a 7-point Likert scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*).

Data analysis

The first two objectives were explored through latent class growth analyses (LCGAs). LCGA are person-centered methods suited for the estimation of between-person differences in within-person change (Jung & Wickrama, 2008).¹ These techniques model heterogeneity in a population by identifying different latent classes of individuals sharing similar longitudinal trajectories (Nylund-Gibson & Choi, 2018). Following the recommendations of Jung and Wickrama (2008), single-class latent growth analyses were firstly conducted to explore the mean intra-individual change of the quality of the CAR. More specifically, both linear and quadratic models were conducted for closeness, commitment and complementarity. Nevertheless, although mean intra-individual growth trajectory can adequately approach a population, there may exist different groups of individuals with specific growth trajectories. Thus, a series of models with increasing numbers of classes was progressively performed for each CAR dimension, in order to determine the best fitting model (Jung & Wickrama, 2008). The identification of the best number of classes is based on several adjustment indexes and statistical tests: The log likelihood value, the Akaike information criterion (AIC), the Bayesian information criterion (BIC), the adjusted BIC (ABIC), the entropy value, and the Bootstrap and Lo Mendell Rubin likelihood ratio tests (BLRT and LMR-LRT) (Nylund-Gibson & Choi, 2018). The best-fitting model is characterised by lower values of AIC, BIC, ABIC, and higher log likelihood value (Jung & Wickrama, 2008). For entropy a cut-off value superior to .80 indicates a good classification of individuals into classes (Nylund-Gibson & Choi, 2018). Moreover, a significant LRTs p -value (i.e., $< .05$) indicates that the n classes model is more adjusted than the $n-1$ classes model. Similarly, these tests allow to compare the best-fitting linear and quadratic model, by evaluating the intercept and the linear and quadratic growth factor for each class. However, the selection of the best fitting models is not only based on the adjustment quality of the model, but also on factors such as classes size ($> 5\%$), theoretical justifications, and a will for parsimony (Jung & Wickrama, 2008).

Finally, latent profile transition analyses (LPTAs) were conducted to observe individuals' changes and/or stability of athletes' profiles of perceived quality of the CAR over the three measurement times. More specifically, in these analyses one profile corresponds to a combination of athletes' perceptions of closeness, commitment and complementarity. Following the recommendations of Nylund-Gibson et al. (2014) a series of cross-sectional latent profile analyses (LPAs) models with increasing number of profiles was firstly performed for each measurement time to determine the best-fitting model. This method considers that each profile is the result of a combination of specific indicators at each measurement time (Nylund-Gibson & Choi, 2018). The same procedure as in the second objective was used to determine the best-fitting model in LPA. Then, simultaneous inclusion of the three measurement times in a series of LPTAs allows to highlight the invariance of the models over the time. More precisely, the invariance of the models was explored by comparing models with total or partial measurement invariance with a

model whose parameters were freely estimated at each time (Nylund, 2007). These comparisons allow evaluating whether athletes' profiles are the same over the three time points. First, a model without constraints (full non-invariance) was compared to a full invariance model (all profiles are forced to be the same across the three measurement times). Then a likelihood ratio test was conducted to identify if these constraints were acceptable: If there was no significant difference between the models, the one with equality constraints was chosen for parsimonious reasons (Nylund, 2007). If there was a significant difference, an iterative procedure was used with n-1 profiles invariant over time.

LCGAs, LPAs, and LPTAs were conducted using Mplus software version 7.31 (Los Angeles, CA, USA) using the full information maximum likelihood estimation for the missing at random data,² as suggested by several authors (e.g., McNeish, 2017).

Results

Descriptive statistics and correlations between closeness, commitment, and complementarity at each measurement time are presented in Table 1.

Table 1. Descriptive statistics.

Variable	M	SD	1	2	3	4	5	6	7	8	9
1. Closeness at T1	5.77	1.10	—								
2. Commitment at T1	5.10	1.25	0.82***	—							
3. Complementarity at T1	5.57	1.24	0.85***	0.83***	—						
4. Closeness at T2	5.62	1.16	0.80***	0.73***	0.73***	—					
5. Commitment at T2	4.72	1.26	0.71***	0.77***	0.66***	0.85***	—				
6. Complementarity at T2	5.40	1.23	0.72***	0.70***	0.72***	0.89***	0.86***	—			
7. Closeness at T3	5.50	1.15	0.73***	0.61***	0.63***	0.77***	0.67***	0.72***	—		
8. Commitment at T3	4.79	1.27	0.63***	0.68***	0.53***	0.66***	0.80***	0.70***	0.77***	—	
9. Complementarity at T3	5.32	1.22	0.64***	0.61***	0.65***	0.72***	0.74***	0.76***	0.86***	0.80***	—

Note. M = mean; SD = standard deviation; T1, T2, T3 = respectively first, second, and third measurement time; * $p < .05$; ** $p < .01$; *** $p < .001$.

Latent class growth analysis

A series of single-class latent growth analysis was firstly conducted in order to capture the mean intra-individual change in the quality of the CAR (see Figure 1). Results revealed that athletes' perceptions of closeness (intercept = 5.77, $p < .001$; slope = $-.14$, $p = .006$) and commitment (intercept = 5.05, $p < .001$; slope = $-.16$, $p = .014$) significantly decreased over the season. Based on the p -value of the LCGA, the evolution of complementarity was not significant over the three measurement times (intercept = 5.55, $p < .001$; slope = $-.12$, $p = .058$). However, multilevel growth curve analyses (see supplemental material) indicated that athletes' perceptions of complementarity significantly decreased in a linear way over time (Time fixed effect = -0.13 , $p = .020$). Based on those elements, the evolution of complementarity may be interpreted as a small decrease over the season. In addition, quadratic models indicated that athletes' perceptions of commitment declined in a non-linear way (intercept = 5.10, $p < .001$; slope = $-.61$, $p < .001$; quadratic = $.22$, $p = .008$). Figure 1 suggests that athletes' perceptions of commitment describe a U-shape over the season, and decrease more strongly in the first part of the season than in the second one.

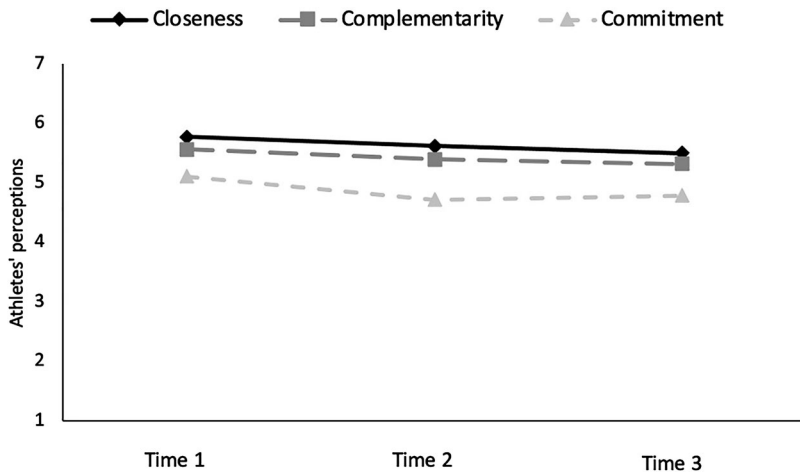


Figure 1. Mean evolution of athletes' perceptions of the coach-athlete relationship.

Then, a series of LCGAs with an increasing number of classes has been gradually computed to explore inter-individual variations in the intra-individual dynamic of the quality of the CAR. Comparison of the LCGAs models (see Table 2) indicated that the three-class model fitted the best for the dimensions of closeness and complementarity. More precisely, there were a notable decreasing for AIC, BIC and ABIC between one and two classes, and between two and three classes. The BLRT also provided evidence that three classes fit better than two or one classes ($p < .001$). Moreover, results indicate that a four-class model does not fit better for complementarity (non-significant LRTs) and implies one class with only three athletes

Table 2. Fit indices of Latent Curve Growth Analyses with 1–5 classes athletes' perceptions of closeness, complementarity, and commitment over time.

	Class 1	Class 2	Class 3	Class 4	Class 5
Number of parameters	5	8	11	14	17
Closeness (linear)					
log likelihood	−340.39	−276.99	−262.67	−255.56	−252.53
AIC	690.78	569.98	547.34	539.32	539.06
BIC	702.69	589.04	573.55	572.67	579.55
ABIC	686.92	563.81	538.86	528.52	525.95
LRT	N/A	−340.39***	−273.99***	−262.67*	−255.66
Entropy	N/A	.93	.88	.89	.79
Complementarity (linear)					
log likelihood	−358.07	−301.98	−289.05	−284.80	−281.98
AIC	726.14	619.95	600.10	597.60	597.97
BIC	738.05	639.01	626.30	630.95	638.46
ABIC	722.28	613.78	591.62	586.80	584.86
LRT	N/A	−358.07***	−301.98***	−289.05	−284.80
Entropy	N/A	.89	.85	.84	.81
Number of parameters	6	10	14	18	22
Commitment (quadratic)					
log likelihood	−363.13	−310.09	−294.34	−285.47	−279.57
AIC	738.25	640.18	617.09	606.93	603.14
BIC	742.54	664.00	650.44	649.81	655.54
ABIC	733.62	632.47	606.29	593.05	586.17
LRT	N/A	−363.13	−310.09	−294.54**	−285.47
Entropy	N/A	.88	.79	.84	.81

Note. AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; ABIC = Adjusted Bayesian Information Criterion; LRT = likelihood ratio test; * $p < .05$; ** $p < .01$; *** $p < .001$.

(3.75%) for closeness, while the minimum recommendations for a class are around 5% of the whole sample (Nylund-Gibson & Choi, 2018). Concerning the dimension of commitment, fit indexes provide support for the 4-class model, and the BLRT indicates that the quadratic four-class model fits better than the linear one ($LRT = 14.27$, $\Delta = 4$, $p < .001$). Consequently, the linear three-class model was retained for closeness and complementarity, whereas the quadratic four-class model was retained for commitment.

The different classes of the LCGAs models for each of the three dimensions of CAR are illustrated in Figure 2. For closeness, the most frequent class, named *high and decreasing* (66.25%; $n = 53$), represents athletes who experienced high levels of perceived closeness with linear decreasing across the three measurement times (intercept = 6.40, $p < .001$; slope = $-.15$, $p = .011$). Then a *moderately high and stable* class (23.75%, $n = 19$) corresponds to athletes who experienced moderate levels of closeness over time (intercept = 5.10, $p < .001$; slope = $-.17$, $p = .239$). Finally, the *low and stable* class (10%, $n = 8$) is composed of athletes who perceived low levels of closeness over time (intercept = 3.47, $p < .001$; slope = $-.053$, $p = .805$).

For complementarity, athletes in the *high and stable* class (52.5%, $n = 42$) experienced high levels of perceived complementarity across the three measurement times (intercept = 6.36, $p < .001$; slope = $-.10$, $p = .167$). The *moderately high and decreasing* class (31.25%, $n = 25$) is composed of athletes who perceived moderately high levels of complementarity which decreased linearly over time (intercept = 5.35, $p < .001$; slope = $-.36$, $p = .002$). Finally, athletes (16.25%; $n = 13$) of the *low and stable* class experienced low levels of complementarity over the 3 measurement times (intercept = 3.44, $p < .001$; slope = $.12$, $p = .581$).

Finally, concerning the dimension of commitment, a *high and stable* class (25%, $n = 20$) is represented by athletes who experienced high levels of commitment across the three measurement times (intercept = 6.08, $p < .001$; slope = $-.24$, $p = .345$). A *moderately high and decreasing* class (48.75%, $n = 39$) is composed of athletes who perceived high levels of commitment but which tended to decline linearly over the season (intercept = 5.38, $p < .001$; slope = -0.49 , $p = .057$). Then the *moderate and unstable* class (17.5%; $n = 14$) represents athletes who experimented a non-linear evolution (i.e., U-shape form) of their perceptions of commitment (intercept = 4.02, $p < .001$; slope = -1.32 , $p = .029$; quadratic = 0.63, $p = .007$). Finally, the *low and stable* class (8.75%, $n = 7$) is represented by athletes who experienced low scores of commitment across the three measurement times (intercept = 2.90, $p < .001$; slope = $-.23$, $p = .635$).

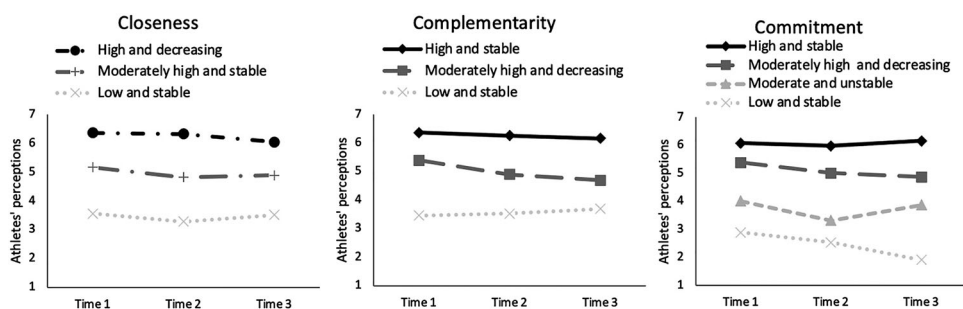


Figure 2. Longitudinal trajectories of athletes' perceptions of the quality of the coach-athlete relationship across the 3 measurement times.

Athletes' evolution within profiles over the season

To explore athletes' evolution within profiles over the season, a series of cross-sectional LPAs models with increasing number of profiles was firstly conducted to determine the best-fitting model for each time point. Then, the invariance of the identified profiles was evaluated.

Cross-sectional latent profile analysis

Results of LPAs are presented in Table 3. The fit indexes indicated that, for T1 and T3, the four-profiles model fits significantly better than all other models. For T2, even though fit indexes provide support for the five-profiles model, this includes a profile with only one athlete (1.25%). For these reasons, the four-profiles model was retained for each measurement time of the study.

Table 3. Fit indices for Latent Profile Analyses with 1–5 profiles of athletes' perceptions of the CAR quality at the three measurement times.

	Class 1	Class 2	Class 3	Class 4	Class 5
Number of parameters	6	10	14	18	22
Time 1					
log likelihood	−362.59	−282.49	−253.41	−245.22	−239.60
AIC	737.18	584.97	534.81	526.44	523.20
BIC	751.16	608.28	567.44	568.40	574.47
ABIC	732.25	576.76	523.31	511.66	505.13
LRT	N/A	−362.59***	−282.49***	−253.41***	−245.22
Entropy	N/A	.97	.88	.90	.90
Time 2					
log likelihood	−357.59	−279.05	−257.53	−234.50	−224.46
AIC	727.17	578.09	543.06	505.00	492.93
BIC	741.00	601.13	575.32	546.48	543.62
ABIC	722.09	569.62	531.20	489.75	474.29
LRT	N/A	−357.59***	−279.05***	−257.53***	−234.50***
Entropy	N/A	.96	.87	.93	.95
Time 3					
log likelihood	−341.37	−292.85	−257.17	−246.00	−239.73
AIC	694.74	605.71	542.33	528.00	523.46
BIC	708.32	628.34	574.01	568.73	573.24
ABIC	689.42	596.83	529.90	512.03	503.93
LRT	N/A	−341.37***	−292.85**	−257.17***	−246.00
Entropy	N/A	.84	.94	.88	.91

Note. AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; ABIC = Adjusted Bayesian Information Criterion; LRT = likelihood ratio test; * $p < .05$; ** $p < .01$; *** $p < .001$.

Latent profile transition analysis

Latent profile transition analyses were conducted to compare a full invariance model (log likelihood = −670.65) which constrained all profiles to be equal across the three measurement times, and a partial invariance model (log likelihood = −660.24) where three profiles on four were forced to be identical over the time, with a full non-invariance model (log likelihood = −654.89) without any constraint. Compared to the full non-invariance model, LRTs revealed a significant worsening of the fit for the full invariance model ($p = .012$), but not for the partial invariance model ($p = .856$), indicating evidence for the latter model. For this reason, the partial invariance model was chosen and proposed the four following profiles (see Figure 3): A *high profile* (i.e., high perceptions of closeness, commitment and

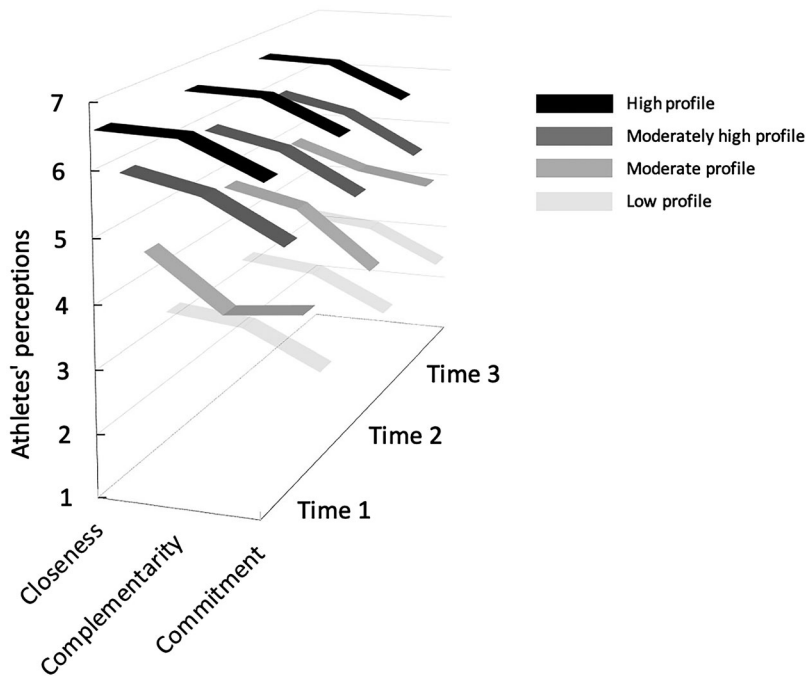


Figure 3. Latent Profile Transition Analyses for the partial invariance model.

complementarity along the three measurement times), a *moderately high profile* (i.e., moderately high perceptions along the three measurement times), a *moderate profile* (i.e., moderate perceptions over the three measurement periods), and a *low profile* (i.e., low perceptions along the three measurement times). Among these four profiles, only one (i.e., the moderate profile) has a changing pattern over time (Figure 3), suggesting that in this profile closeness remained stable, whereas complementarity was higher in the second part of the season than the in the first one, and commitment decreased between T1 and T2 and increased between T2 and T3. The three other profiles (i.e., high, moderately high, and low) present stable patterns over time.

Results of probabilities transitions (Table 4) indicate that most athletes have high probabilities (from 67.4 to 100%) to stay in the same profile over the season. However, results also suggest that some athletes have changed their profiles over time. Indeed, athletes of the high profile at the beginning and the middle of the season had probabilities (from 12.3 to 27.6%) to switch to the moderately high and moderate profiles at the following measurement time. In addition, athletes of the moderately high profile were the most likely to move to other profiles over time (from 3.9 to 23.8%). Finally, athletes of the moderate and low profiles did not change between the beginning and the middle of the season, but some of them switched to the other profile at the end of the season (8.5 and 29.8%).

Discussion

The present study proposed to examine the temporal dynamic of the quality of the CAR through the lens of the 3+1Cs model among adolescent handball players over a one-

Table 4. Probabilities of athletes' profiles transitions across measurement times.

Time 1	Time 2			
	High profile	Moderately high profile	Moderate profile	Low profile
High profile	0.724	0.276	0	0
Moderately high profile	0.048	0.674	0.238	0.039
Moderate profile	0	0	1	0
Low profile	0	0	0	1
Time 2	Time 3			
	High profile	Moderately high profile	Moderate profile	Low Profile
High profile	0.743	0.123	0.134	0
Moderately high profile	0.121	0.794	0.085	0
Moderate profile	0	0	0.915	0.085
Low profile	0	0	0.298	0.702

season period. For this, a three-wave design was conducted to explore the evolution of athletes' perceptions of closeness, complementarity, and commitment, in three complementary ways: mean intra-individual change, inter-individual differences between athletes, and athletes' intra-individual stability and/or change of CAR profiles.

Firstly, multilevel growth curve and latent class growth analyses revealed that athletes' perceptions of closeness, complementarity, and commitment decreased – on average – over the course of the season. This result is consistent with the previous findings of Gardner et al. (2018) suggesting that the CAR quality perceived by young athletes slightly decreased over a one-year period. By using a three-wave design and growth models to analyze the data, the present study is the first to bring solid elements in favour of the existence of temporal evolution of the quality of the CAR. More specifically, the mean-sample intra-individual analyses revealed that athletes' perceptions of closeness and complementarity declined linearly over time, whereas athletes' perceptions of commitment decreased in a non-linear way, with a stronger decline in the first part of the season. Effect sizes of these changes were moderate (see Cohen's *d* in supplementary material) and provide support for the evolving nature of the CAR quality (e.g., Antonini Philippe et al., 2011). In addition, multilevel growth curve analyses (see supplementary material) suggest that these changes in the quality of the CAR do not vary depending on the training centres. These results suggest that the temporal dynamics of the CAR quality observed in this study can be considered as relatively robust. Potential explanations of these findings may partly lie in some characteristics of both context and sample of this study. Indeed, it could be assumed that the accumulation of numerous physical, emotional, and social constraints in intensive training centres may lead to emotional disturbances among athletes (Cece et al., 2019), and a deterioration of interpersonal processes between coach and athletes resulting in a decline of athletes' perceptions of the quality of the CAR. For example, coaches in intensive training centres may have particularly high expectations and goals toward their athletes, leading these athletes to perceive this context as pressuring and controlling. As suggested by previous studies (e.g., Fouraki et al., 2020), athletes' perceptions of pressuring and controlling coaches' behaviours may be responsible for the deterioration of their perceptions of CAR quality over time. In addition, most athletes involved in these training centres have the goal to become a professional player. For this they are notably dependent on their relation with the coach. If this relation deteriorates, athletes may not be retained the next season, and thus compromise the possibility to achieve their goal. Athletes who perceive this risk may develop

some strategies (e.g., cooperate to resolve a conflict) to maintain a sufficient level of commitment with their coach, in order to achieve their long-term goal (Rhind & Jowett, 2012). As these explanations are speculations, studies are needed to identify the underlying processes involved in these results. Moreover, the identification of specific temporal trajectories for closeness and complementarity (i.e., a linear decrease) and commitment (i.e., a non-linear decrease) could encourage future work to explore these dimensions concurrently, rather than using an overall indicator of CAR quality as it is often done in the literature (e.g., Isoard-Gauthier et al., 2016). This could lead to a more in-depth understanding of these dimensions.

Secondly, the use of a person-centered approach highlighted some inter-individual differences in the intra-individual dynamic of athletes' perceptions of the CAR quality. Indeed, LCGAs revealed the existence of three distinctive classes of athletes' perceptions of closeness and complementarity, and four classes for commitment. Specifically, most athletes experienced a linear decrease of their perceptions of the CAR (i.e., athletes from the high and decreasing class of closeness, and the moderately high and decreasing classes of complementary and commitment) whereas some athletes had stable perceptions of the quality of the CAR over the season (i.e., athletes from the moderately high/low and stable classes of closeness, the high/low and stable classes of complementary and commitment). Finally, a small part of the athletes experienced a non-linear evolution of their perceptions of the quality of the CAR (i.e., moderate and unstable class of commitment). With these results the present study is the first, to our knowledge, to reveal inter-individual differences in the intra-individual dynamic of the quality of the CAR. These distinct trajectories may result from variability in some interpersonal factors (e.g., degree of coaches' controlling behaviours) as suggested above, as well as in some athletes' individual characteristics. Previous studies notably indicated that athletes' personality traits may be a significant predictor of their perceptions of CAR quality (e.g., Yang et al., 2015). More precisely, athletes' levels of agreeableness, extraversion and conscientiousness positively predicted their perceptions of the CAR quality, while neuroticism predicted them negatively. Thus, inter-individual differences in athletes' personality traits may partially explained the distinct trajectories of the CAR quality. Furthermore, because some athletes of the present study were in their first year in the training centre, whereas others were in their third year, the length of the relationship with the coach was not the same for all athletes. As suggested by Jowett and Clark-Carter (2006) the length of the relationship is a potential moderator of the changes in athletes' perceptions of the quality of the CAR over time, and thus could partially explain the inter-individual variability in athletes' perceptions observed in the present study. Based on these suggestions, future works are encouraged to explore the role played by interpersonal and individual factors in the temporal dynamics of the CAR quality.

Finally, the LPTA approach explored the stability and/or change in the intra-individual dynamic of the profiles of CAR (Figure 3), by analysing individuals' transition probabilities of profiles across the three measurement times. Results revealed that although most of the athletes stayed in the same profile over the season, some of them changed their profile. Overall, these results provide support for the evolutive nature of the CAR (e.g., Antonini Philippe et al., 2011) and highlight the importance of considering inter-individual differences and the use of a person-centered approach (Laursen & Hoff, 2006) to explore the temporal evolution of the CAR quality. Moreover, LPTAs also allowed to

explore how the different dimensions of the CAR quality related to each other. On this point, results of the present study support the idea that closeness, commitment and complementarity evolve in a synergistic way, and that closeness, commitment and complementarity are interdependent dimensions (Jowett & Ntoumanis, 2004). They underline the importance for future work of exploring the quality of the CAR in terms of closeness, commitment and complementarity. Further studies are needed to explore the underlying mechanisms of these results and the person-situation interactions that could differentiate athletes characterised by changes versus stability in their CAR profiles.

Limitations and perspectives

Although this study contributes to current knowledge on the temporal dynamic of the quality of the CAR, it has some limitations that are all avenues for future research.

Firstly, given the specificity of our sample, caution should be exercised before generalising the findings. It is likely that there are some components of the intensive training centres that do not apply in other sport contexts. For instance, in intensive training centres, if athletes do not perform or progress over the season – according to their coach's expectations – they may not be maintained into the training centre the following year. As a consequence, the evolution of their perceptions of the CAR quality could be impacted by the fear of not being conserved in the centre the next season. Therefore, the quality of the CAR may have different developmental trajectories in other contexts, which warrant further research.

Furthermore, although the use of three measurement times is a strength, allowing to explore the potential non-linear evolution of the CAR quality over the sport season, it could also be considered as a limitation. In the present study, the measurement times were spaced from each other by three months. Significant events (e.g., a major success or failure) are likely to occur during these periods, and may have consequences on the dynamics of the CAR quality (Sagar et al., 2010). Future studies including more frequent assessments of athletes' perceptions of the CAR quality and of environmental (e.g., success/failure) or interpersonal variables (e.g., coaches' expectations toward the athletes) could help to capture a deeper understanding (and mechanisms involved in) of the evolution of the CAR quality over time (Van der Nest et al., 2020).

Moreover, the sample size of the present study may influence the results of data-driven analyses used. A larger sample might allow for the identification of different patterns of change in the quality of the CAR. However, some authors suggested that relatively small samples may be adequate for simple models (e.g., few indicators) and distinguishable classes (Nylund-Gibson & Choi, 2018). On this point, because the present study explored models with only three indicators (i.e., the 3Cs) and revealed good distinguishability between the latent profiles (all entropy values $>.80$; see Tables 2 and 3), the sample size can be considered as acceptable. In any case, further works are needed to evaluate the temporal dynamic of the CAR among larger and various samples in terms of sports practiced (e.g., individual sports), characteristics of athletes (e.g., older athletes) and context of practice (e.g., professional).

Another interesting perspective could be to investigate potential consequences of the specific profiles and temporal trajectories revealed by the present study. For example, exploring to what extent temporal changes in the perception of the quality of the

CAR generate changes in athletes' characteristics such as motivational orientations or burnout (e.g., Isoard-Gautheur et al., 2016) may bring a more complete picture of these process.

Finally, another limit of the present study is that the quality of the CAR has only been measured from the athletes' perspective. Studies including both coaches' and athletes' perspectives would provide a broader picture of the temporal evolution of the CAR. For example, the examination of the direct and meta-perceptions (e.g., Jowett, 2009) of both athletes and coaches could allow to explore the dynamic of co-orientation within the dyad (i.e., degree of concordance between coaches and athletes' interpersonal perceptions regarding the quality of the CAR). Studies revealed that the degree of co-orientation between athletes and coaches positively predict some emotional incidences (e.g., satisfaction, Jowett & Clark-Carter, 2006). Nevertheless, to date no study explored the temporal evolution of co-orientation between athletes and coaches, as well as its potential consequences. Future studies are encouraged to fill this gap.

Despite the aforementioned limitations, this study makes a unique contribution to the literature on the CAR by examining the temporal dynamics of closeness, commitment, and complementarity, from the athletes' perspectives over a one season period. Indeed, although previous studies suggested that the CAR quality was a dynamic process (e.g., Jowett & Poczwardowski, 2007), the present study offers solid empirical evidence concerning the different aspects of the temporal evolution of this relationship (i.e., mean intra-individual change, inter-individual differences between athletes, and athletes' intra-individual stability and/or change). This study also provides interesting elements for coaches focused on sports performance-related issues. Precisely, because the CAR quality is considered as a key element in the athlete's development (Jowett, 2007), understanding the temporal evolution of athletes' perceptions of closeness, commitment, and complementarity may bring relatively important information for coaches. For example, it may allow coaches to identify the profile of each athlete and how its profile evolve over time. From an applied perspective, it could be used to help coaches to identify athletes whose perceptions of CAR quality decline over time, as well as anticipate periods in which the quality of the CAR (perceived by athletes) is likely to deteriorate. Based on these elements, coaches could develop some relational strategies (e.g., COMPASS model; Rhind & Jowett, 2012) to prevent these periods, and thus maintain high levels of closeness, commitment, and complementarity with their athletes. Thus, given the importance of CAR in competitive sport context, continued research is warranted to understand the antecedents and consequences of the temporal dynamics of CAR.

Notes

1. Multilevel Growth Curve Analyses (MGCA) were complementary performed to deal with the nested structure of the data (Muthén, 2004). Results of MGCA were similar to those of the 1-class models in LCGAs. For interested readers results of MGCA are available in the supplemental material.
2. In intensive training centres, athletes can be excluded if they adopt inappropriate behaviours (e.g., lack of attendance at training sessions). Consequently, when athletes miss a training session it is mainly due to injury or medical appointments. For this reason, missing data were consider as missing at random.

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