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Longitudinal associations between coach-athlete relationship quality and individual injury rate among young handball players: A variable and person-centered approach in intensive training centers

Valentin Roux^{1,2}  and David Trouilloud² 

Abstract

This study explores the potential associations between the evolution of coach-athlete relationship quality (in terms of closeness, commitment, and complementarity) and the athletes' individual injury rate over a sport season. 203 young French handball players (Mage = 15.38, 47.3% women) involved in intensive training centers completed a French version of the Coach-Athlete Relationship Questionnaire at the beginning, middle, and end of the season. The athlete follow-up allowed their individual injury rate over the season to be captured. Both variable and person-centered approaches were used to explore the temporal associations between these variables. A linear growth model and a multiple regression analysis indicated that the evolution of coach-athlete relationship quality was negatively related to athletes' individual injury rate over the season. In addition, latent class growth analyses and ANOVA revealed inter-individual differences in the evolution of this association, indicating that athletes who perceived a deterioration in the relationship with their coach were more often injured during the season. This study is the first to highlight a temporal association between coach-athlete relationship quality and athletes' individual injury rate over time, and thus provides stimulating perspectives for future research.

Keywords

3 + 1Cs model, closeness, commitment, complementarity, psychosocial

For more than twenty years, the undesirable consequences of athletes' injuries on their performance (e.g., ranking) and financial issues (e.g., post-traumatic care costs) for clubs and health systems have been highlighted.¹ In view of these elements, the identification of the mechanisms involved in the occurrence of athletes' injuries has become an important issue in sport sciences.² While research has mainly focused on physiological, anatomical, and/or biomechanical factors,³ it is noteworthy that a steadily growing number of studies have been examining the role played by psychological factors on the risk of injury over the past twenty years.^{4,5} Nevertheless, whereas the influence of some intra-individual psychological factors (e.g., trait anxiety) is now well established in the current literature,⁶ some theoretical models have suggested that psychosocial factors may also be involved in injury risk. More precisely, several models (e.g., the stress-injury model,⁷ the multilevel model of sport injury,⁸ the biopsychosocial model of injury⁹) suggest that negative life events such as conflicting interpersonal relationships may have physiological (e.g., higher muscle tension) and attentional (e.g.,

lower peripheral vision) implications which are likely to increase injury risk. On this point, a poor coach-athlete relationship (CAR) is considered by both coaches and athletes as an injury risk factor.^{10,11} Some studies have begun to empirically explore this topic. Qualitative studies have indicated that conflict and poor communication in the CAR could be considered as a potential extrinsic risk factor for injuries.^{10,11} For example, Cavalliero et al.¹² suggested that gymnasts may be afraid to talk to their coach about their pain, fearing that the coach does not consider them

to be mentally tough enough. This lack of communication may lead to a worsening of the pain and athletes' injuries. In addition, some quantitative studies have found that the coach's leadership style was related with injury risk. For example, Ekstrand et al.¹³ indicated that the incidence of serious injuries was lower in teams where the coach communicates a positive attitude (e.g., optimism), supports the athletes, and regularly encourages them. Coaches may unintentionally expose athletes to injury risk when they adopt a leadership style that hinders optimal functioning. More precisely, these authors suggested that a performance-oriented motivational climate induced by the coach (i.e., one which fosters social comparison between athletes) leading to high athlete effort can lead to an increased risk of injury. However, interest in the study of the relations between CAR characteristics and injury risk is relatively recent and rare in the literature. In addition, in these studies, the CAR has been explored through various concepts – such as communication and leadership – limiting understanding of the CAR to some specific aspects (e.g., coaching behaviors). The literature would benefit from exploring the CAR through a more systemic approach and grounded-theory studies to enhance understanding of the associations between the CAR and injury risk.

On this point, the 3 + 1Cs model¹⁴ is considered a systemic model for exploring the various processes involved in the CAR. In its essence, the 3 + 1Cs model suggests that the quality of the CAR can be conceptualized into a model comprising the 4 dimensions of closeness, commitment, complementarity, and co-orientation. Closeness corresponds to the affective dimension of the CAR and reflects the mutual feelings of respect, trust, and confidence between the coach and their athletes. Commitment represents the cognitive characteristics of the CAR and is characterized by the intentions of both the coach and their athletes to maintain their relationship over time to achieve common goals. Complementarity corresponds to the behavioral dimension and refers to the actions of cooperation of the dyad's members. Finally, co-orientation describes the degree of understanding of the other and the level of similarity between the coach and their athletes concerning their perceptions of closeness, commitment, and complementarity. This model has been the most commonly used in the last twenty years, and associations of the CAR quality with affective, motivational, and performance-related processes have been well-established.¹⁵ For instance, several studies indicated that athletes experiencing low levels of CAR quality were more likely to feel physically and emotionally exhausted,¹⁶ and produced higher markers of physiological stress such as salivary cortisol.¹⁷ In addition, the consequences associated with a poor CAR appear to be particularly important in stressful contexts such as intensive training centers.¹⁸ Indeed, athletes involved in these types of structures are exposed to several physical, emotional, and social constraints such as high expectations and

demands from the coach¹⁹ which are likely to affect injury risk. However, little is known about any potential association between the CAR quality and injury risk. To the best of our knowledge, only one recent study has investigated this issue, and it suggested that the quality of the CAR may be related to athletes' overuse injuries.²⁰ Nevertheless, because this study explored athletes' profiles based on several characteristics (i.e., negative life stress, personality traits, athletic identity, and perceived CAR quality), it did not allow the identification of specific relations between CAR quality and injury risk. In addition, although the CAR can be considered as a dynamic process likely to evolve over time²¹ and that the prospective study of Martin et al.²⁰ explored the injuries using weekly measures, in this study the quality of the CAR was measured at only one point in time. This could not capture the temporal association between the CAR quality and injury risk. As a result, even though recent reviews²² have emphasized the importance of exploring this line of research and conducting further studies on this topic, there remains a lack of knowledge on the potential association between CAR quality and injury risk over time. On this point, to our knowledge no study has investigated the association between changes in the CAR quality and injury risk. However some authors have suggested that a significant deterioration in the CAR quality could be related to breakdown interactions and communication between coach and athlete, which could be associated with negative consequences such as increasing stress levels and burnout.^{23,24} Based on these elements, exploring the evolution of the CAR would not only contribute to a better knowledge of the dynamic characteristics of the CAR quality, but would also provide a better understanding of its consequences over time. The present study aims to fill this gap.

The present study

The main purpose of this study is to explore the associations between the temporal evolution of the athletes' perceptions of CAR quality (in terms of closeness, commitment, and complementarity) and individual injury rate over 1 season, among young handball players involved in intensive training centers. More precisely, this purpose is approached through a complementary variable and person-centered approach²⁵ to explore (1) whether changes in the athletes' perceptions of the CAR quality over the season were associated with their individual injury rate (i.e., the intra-individual level); and (2) the existence of differences between athletes within this association (i.e., the inter-individual level). At the intra-individual level, it is expected that the evolution of CAR quality is negatively associated with athletes' individual injury rate over the season. Considering the importance of previous injury experiences on athletes' later injuries,²⁶ this variable was controlled for

in our analyses. At the inter-individual level, we hypothesize that athletes experiencing a positive evolution and/or a high perception of the CAR through the season are associated with lower individual injury rate, compared to athletes with low and/or decreasing CAR quality trajectories.

Method

Participants and procedure

Two-hundred and three young French handball players (96 females, 47.3%) involved in eight intensive training centers (with one coach for each center) participated to this study. They were on average 15.38 years old ($SD = .94$) and practiced at national ($n = 134$, 66%) and regional ($n = 69$, 34%) levels. The athletes trained an average of 3.54 times per week ($SD = 1.52$), corresponding to a weekly handball practice duration of 7.12 h ($SD = 3.03$) within the center. In addition to handball training sessions, athletes also had at least two sessions per week of physical training.

Three measurement times were conducted, at the beginning, middle, and end of the season. The managers of the training centers were contacted in advance to obtain their agreement for the implementation of the present study among athletes. At the first measurement time, the researcher (without coach) presented the study to the athletes before their training session. Then a written consent form summarizing the aim of the study, and confirming that participation was voluntary and that they could withdraw at any time by informing the researchers, was given to all participants (and their parents by mail before the beginning of the study). It was also indicated that the coach was not present during the session and will not be able to access to their answers. The athletes completed the questionnaires in person before a training session in a dedicated room. Institutional ethics approval for noninterventional studies was obtained from the authors' university (Ethics approval number: IRB00010290-2018-10-16-53 CER Grenoble Alpes).

Measures

Coach-athlete relationship quality. Athletes completed the 11-item French version of the Coach-Athlete Relationship Questionnaire (CART-Q)^{21,27} at the beginning, middle, and end of the season. This scale allowed us to measure athletes' perceptions of closeness (4 items; e.g., "I like my coach"; $\alpha > .83$; $\omega > .84$), commitment (3 items; e.g., "I am committed to my coach"; $\alpha > .76$; $\omega > .76$), and complementarity (4 items; e.g., "When I am coached by my coach, I am ready to do my best"; $\alpha > .73$; $\omega > .74$), to their head coach. CART-Q items were collected on a 7-point Likert scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). Considering the very high correlations between the dimensions of closeness, commitment, and

complementarity ($r_s > .72$ at each measurement time) and strong statistical evidences for a second-order model in the literature,²⁸ an overall indicator of CAR quality was computed and used in the present study.

Athletes' individual injury rate. Injury risk has been explored through time-loss injury. According to Fuller et al.²⁹ and Jacobsson et al.³⁰ this conceptualization suggests that athletes should be considered as injured when they are unable to fully take part in the session and requiring a total removal from the training session or competition. For this, the athlete follow-up databases filled in by the managers of the training centers were used to assess the athletes' time-loss injury over the season. More specifically, each manager completed a daily file recording information on each athlete, such as attendance at training sessions and the number of training sessions missed due to injury. For each handball training session, each athlete was considered by the managers as "injured" in the file when they were unable to fully take part in the training session. In accordance with the consensus statement on injury definitions²⁹ and the recommendations of previous studies,³¹ a ratio was calculated to measure the athletes' individual injury rate over the whole season, and only handball training sessions in the centers were taken in account in this measurement. Specifically, this individual injury rate was calculated by the ratio of the number of handball training days an athlete was considered injured (i.e., sessions lost) to the theoretical number of handball training sessions (i.e., training exposure) between the first and third measurement times.

Data analysis

Firstly, a variable-centered approach was used to explore whether the evolution of athletes' CAR quality perceptions was associated with athlete individual injury rate at the intra-individual level. For this, a variable representing the mean evolution of the CAR quality over time was created. Given the hierarchical and longitudinal nature of the data, multilevel growth models were used,³² and a linear growth model was conducted to extract the growth coefficient of the evolution of the CAR quality for each athlete. Then, a multiple regression analysis was performed in order to explore the associations between athletes' perceptions of CAR quality evolution and their individual injury rate during the season, with previous individual injury rate as a covariate¹. Multilevel growth models and multiple regressions were performed with Rstudio 4.1.0³³ software (PBC, Boston, USA) using the "lme4"³⁴ and "lmer"³⁵ packages.

Secondly, a person-centered approach was used to analyze these associations at the inter-individual level. More precisely, latent class growth analyses (LCGA) were used to explore inter-individual differences concerning the associations between the temporal evolution of the

CAR quality and athletes' individual injury rate. For this, based on athletes' perceptions of the CAR at each measurement time, a series of linear models with an increasing number of classes – including previous individual injury rate as predictor of individual injury rate over the whole season in the model – were tested.³⁶ The following fit indices and statistical tests were used³⁷ to identify the best number of classes: the log likelihood value, Akaike information criterion (AIC), Bayesian information criterion (BIC), adjusted BIC value (ABIC), entropy, and Bootstrap and Lo Mendell Rubin likelihood ratio tests (BLRT and LMR-LRT). The best-fitting model is characterized by lower values of AIC, BIC, ABIC, and higher values of log likelihood and entropy,³⁷ and LRT comparison tests allow us to determine the model with the most adequate number of classes. Other parameters such as classes size (greater than 5% of the sample), the theoretical sense of the classes, as well as parsimony must be considered to identify the best-fitting model.³⁷ Then, the intercept and slope values of the classes provided by LCGA were used to characterize their trajectories. LCGA were conducted using Mplus 7.31 software (Los Angeles, CA, USA).³⁸

After identifying the best-fitting number of classes, each athlete's membership in the different classes was extracted from the model, and an ANOVA was conducted to explore whether the identified classes differed in terms of individual injury rate over the season. The ANOVA was performed using the "lmerTest" package³⁹ of the Rstudio 4.1.0³³ software.

Results

Intra-individual level

The multiple regression [$F(2, 200) = 19.80, p < .001$] indicates that the athletes' individual injury rate during the season was negatively related to the evolution of their perceptions of the CAR quality ($\beta = -0.17, p = .008$) and positively related to previous individual injury rate ($\beta = 0.36, p$

$< .001$) (see Table 1). Thus, the evolution of athletes' perceptions of the quality of the CAR appears to be a potential antecedent of athletes' individual injury rate, independently of the association with earlier injuries.

Inter-individual level

The results of the model comparisons (see Table 2) indicate that the 5-class model is the best fit for athletes' perceptions of CAR quality over the season. Indeed, there is a significant decrease in AIC, BIC, and ABIC until the 5-class model. In addition, BLRT indicates that the 5-class model fits better than the 4-class model ($p < .001$). Moreover, although the fit indices continue to decrease slightly for the 6- and 7-class models, these models contain 1 or more classes representing less than 5% of the sample. Given these elements, the 5-class model was retained.

Then, the values of the intercept and slope of the classes provided by the LCGA results were used to characterize the trajectories of the CAR quality over time. The 2 most frequent classes, named *moderately high and stable* ($n = 76; 37.4%$) and *high and stable* ($n = 55; 27.1%$), represent athletes experiencing moderately high (intercept = 5.20, $p < .001$; slope = 0.02, $p = .68$) and high (intercept = 6.05, $p < .001$; slope = 0.003, $p = .93$) levels of CAR throughout the season, respectively. The *moderate and increasing* class ($n = 36; 17.7%$) corresponds to athletes who perceived moderate but increasing levels of CAR quality over the season (intercept = 3.91, $p < .001$; slope = 0.19, $p = .02$). The *moderate and decreasing* class ($n = 24; 11.8%$) represents athletes who experienced moderate levels of CAR quality that deteriorated over time (intercept = 3.74, $p < .001$; slope = $-0.43, p = .055$). Finally, athletes in the *high and decreasing* class ($n = 12; 6%$) perceived high but decreasing levels of CAR quality over the season (intercept = 5.78, $p < .001$; slope = $-0.27, p = .04$). Figure 1 represents the trajectories of CAR quality for the 5 classes identified.

Table 1. Results of the multiple regression for athletes' individual injury rate.

Independent variables	b	SE	B	β	β	Fit
			95% CI [LL, UL]		95% CI [LL, UL]	
(Intercept)	0.09**	0.01	[0.06, 0.12]			
Evolution of athletes' perceptions of the CAR quality over the season	-0.26**	0.10	[-0.45, -0.08]	-0.17**	[-0.30, -0.06]	
Individual injury rate before T1	0.41***	0.07	[0.17, 0.71]	0.36***	[0.16, 0.58]	
						$R^2 = .17^{**}$
						95% CI [.06, .35]

Note. T1 = First measurement time; b = non-standardized regression coefficient; SE = Standard error; CI = Confidence interval; LL = Lower limit; UL = upper limit; β = standardized regression coefficient; Fit = percentage of variance explained; * $p < .05$; ** $p < .01$; *** $p < .01$.

Table 2. Fit indices of latent class growth analyses with 1–7 classes for athletes’ perceptions of the CAR quality over time.

	1 class	2 classes	3 classes	4 classes	5 classes	6 classes	7 classes
Number of parameters	8	12	16	20	24	28	32
log likelihood	-735,00	-614,31	-577,08	-549,39	-530,21	-515,04	-498,19
AIC	1486,00	1252,63	1186,16	1138,77	1108,43	1086,08	1060,38
BIC	1512,51	1292,38	1239,17	1205,04	1187,95	1178,84	1166,40
ABIC	1487,16	1254,37	1188,48	1141,67	1111,91	1090,14	1065,02
LRT	NA	-735,00***	-614,313***	-577,08***	-549,39***	-530,21***	-515,04***
Entropy	NA	0,88	0,92	0,82	0,82	0,86	0,87
n by class	203	63	61	74	24	8	9
		140	12	76	55	57	55
			130	12	76	15	9
				41	36	12	75
					12	75	36
						36	8
							11

Note. n = Number of athletes in each class; AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; ABIC = Adjusted Bayesian Information Criterion; LRT = likelihood ratio test; * $p < .05$; ** $p < .01$; *** $p < .001$.

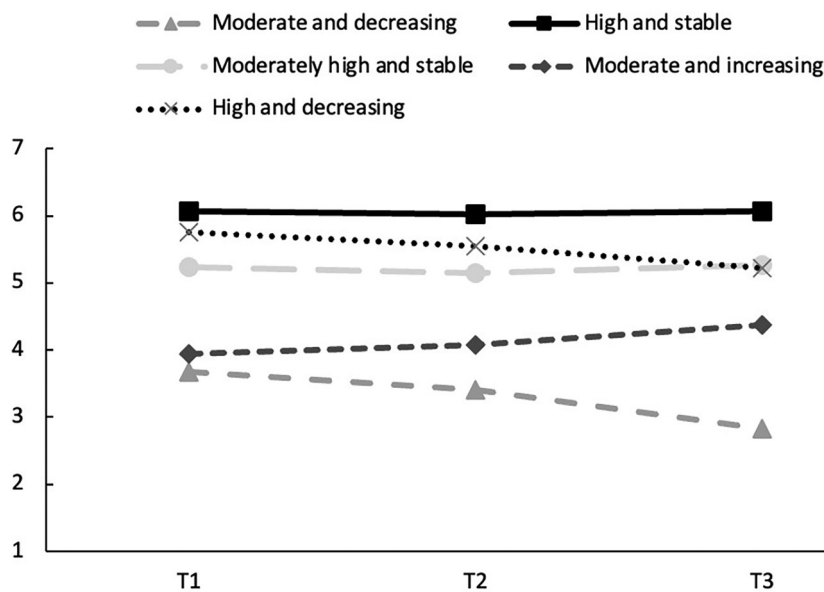


Figure 1. Trajectories of the five identified classes of CAR quality as perceived by the athletes.

In a second step, the class membership of each athlete was extracted, and an ANOVA was conducted to compare whether the 5 classes identified differed significantly concerning athletes’ individual injury rate values over the season. The mean scores of individual injury rate corresponding to each class are presented in Table 3. For example, the average individual injury rate in the *high and stable class* is 6%, indicating that athletes who perceived a high and stable CAR quality with their coach over the season missed only 6% of the overall training sessions due to injury. On this point, the results revealed the existence of significant differences between the 5 classes [$F(4, 198) = 73.63, p < .001$]. Specifically, Bonferroni’s

Post Hoc comparison tests (see Table 3) indicate that athletes in the *high and decreasing class* were significantly more often injured during the season compared to athletes in the 4 other classes ($p < .001$). Furthermore, athletes in the *moderate and decreasing class* had a higher individual injury rate than those in the *high and stable* ($p < .001$), *moderately high and stable* ($p = .03$), and *moderate and increasing* ($p = .01$) classes.

Discussion

The aim of this study was to explore the temporal associations between the evolution of athletes’ perceptions of the

Table 3. Results of Bonferroni's Post Hoc tests between classes.

Class compared (N)	Minjury	Classes (N)	Minjury	Difference	SE	P
Moderate and decreasing (24)	0.19	High and stable (55)	0.06	0.13	0.03	< .001
		Moderately high and stable (76)	0.10	0.09	0.03	0.03
		Moderate and increasing (36)	0.08	0.11	0.03	0.01
		High and decreasing (12)	0.72	-0.53	0.04	< .001
High and stable (55)	0.06	Moderately high and stable (76)	0.10	-0.04	0.02	0.76
		Moderate and increasing (36)	0.08	-0.02	0.03	1.00
		High and decreasing (12)	0.72	-0.66	0.04	< .001
Moderately high and stable (76)	0.10	Moderate and increasing (36)	0.08	0.02	0.03	1.00
		High and decreasing (12)	0.72	-0.62	0.04	< .001
Moderate and increasing (36)	0.08	High and decreasing (12)	0.72	-0.64	0.04	< .001

Note. N = Number of athletes per class; Minjury = Mean score of individual injury rate in the class; SE = Standard error.

CAR quality and their individual injury rate over 1 season, through a longitudinal design and a complementary variable and person-centered approach. The results partially supported our hypotheses based on the theoretical tenets of the 3 + 1Cs and athlete injury models.

First, the variable-centered analyses revealed a negative association at the intra-individual level between athletes' perceptions of the CAR quality and their individual injury rate over the season. This result suggests that a deterioration in athletes' perceptions of the level of closeness, commitment, and complementarity between themselves and their coach increases their risk of getting injured. It provides support for our first hypothesis and for theoretical models suggesting that negative interactions and coaching practices are likely to increase athletes' individual injury rate.⁸ By adopting a 3 + 1Cs model perspective, these findings add new elements to the existing literature on this topic. Indeed, to the best of our knowledge, the present study is the first to explicitly highlight an association between the evolution of athletes' perceptions of closeness, commitment, and complementarity within their CAR and their individual injury rate over the course of a sport season. On this point, the present study brings complementary findings which add to previous research on this topic indicating that some aspects of the CAR such as the transformational leadership of the coach may be related to injury risk.¹³ From an interpersonal point of view, the multilevel model of sport injury⁸ provides some insights to discuss these elements, suggesting that coaching practices and demands involved in these types of training centers¹⁹ such as rewarding unyielding dedication to train and achieve perfection may lead to athlete injury. Specifically, these practices and the deterioration in the quality of the CAR can be perceived by athletes as particularly stressful periods regarding their uncertain future in the center, likely in turn to raise their risk of injury.⁷ Moreover, other studies suggested that the communication in the CAR could be considered as an important interpersonal factor to take in account in the prevention of injury risk.¹² For instance, athletes with a high but decreasing CAR quality would start to communicate

less and less over the season, which led to higher training mistakes and risk of injury in comparison to athletes with a lower CAR quality who were already used to a lack of communication. In addition, the present study supports the evolving nature of the CAR underlined in previous studies,^{21,40} and provides evidence of the relevance of the 3 + 1Cs model in exploring the associations between the CAR and sport injuries through a longitudinal perspective.

Secondly, the person-centered analyses revealed differences among athletes at the inter-individual level concerning the associations between the temporal evolution of the quality of the CAR and athletes' individual injury rate. More precisely, the results revealed that athletes who experienced negative and/or declining perceptions of their level of closeness, commitment, and complementarity with their coach over time were the most likely to be injured during the season. In other words, these results suggest that regardless of the level of CAR quality perceived at the beginning of the season, the athletes who experienced the highest injury rates were those who perceived a deterioration in levels of closeness, commitment, and complementarity with their coach over the season. However, the results of the present study also indicated that athletes who experienced a high but decreasing CAR quality were more often injured than those who perceived moderate and decreasing levels of closeness, commitment, and complementarity over time. This result is more unexpected, but highlights the importance of exploring CAR dynamics through complementary analysis methods. Indeed, by exploring both the intensity and the evolution of the quality of the CAR through person-centered and variable-centered approaches, the present study reveals intra- and inter-individual differences in the temporal evolution of this variable. More precisely, these findings suggest that beyond consideration of the level of the CAR quality, its temporal evolution seems to be an important characteristic too. For instance, one may think that athletes who perceived high levels of CAR quality at the beginning of the season might experience the deterioration of the relationship more negatively than athletes who already had a

poor relationship with their coach at the beginning of the season. According to the stress-injury model,⁷ the emotions and thoughts associated with this negative life event could lead to higher stress levels for these athletes, likely to be related to athletes' individual injury rate. These suggestions provide interesting perspectives and underline the need for further studies in this area.

Limitations and perspectives

Although the present study contributes to the literature on the psychosocial antecedents of athletes' injuries by suggesting that the evolution of the quality of the CAR may be an important factor in the athletes' individual injury rate, some limitations and perspectives need to be considered for future research.

The first limitation relates to the correlational nature of the data, which means that the potential causality between the CAR quality and athletes' individual injury rate should be considered with caution. Indeed, even though the results of the present study are in accordance with our hypotheses and support previous findings,²⁰ a reciprocal relationship between these variables may be considered. For instance, the hypothesis that an athlete's injury could have a negative impact on the quality of CAR cannot be excluded. More studies using a range of designs (e.g., cross-lagged and/or experimental designs) are encouraged to better identify the causal links between these variables. For instance, on the basis on the recommendations of Shanmugam & Jowett⁴¹ and the proposals of the COMPASS model,⁴² it could be interesting to conduct an interventional study to examine whether coaches can be trained to develop/maintain a positive CAR. Repeated measures of the quality of the CAR (perceived by both coaches and their athletes) and injury risk will allow to determine whether athletes whose coaches were trained to develop/maintain positive CAR were less injured over time.

Furthermore, another limitation related to the measurement of athletes' injuries needs to be considered. Although the measure used in the present study focused on the time-loss injury definition^{29,30} (i.e., the amount of time for which athletes were unable to fully take part and requiring a total removal from the handball training session in the center during the season), it did not allow the severity of athletes' injuries, or their acute or chronic nature, to be captured. On this point, some research has suggested that acute injuries are more likely to be related to athletes' cognitive appraisals (e.g., reduced peripheral and central vision) during potentially stressful situations,⁴³ whereas overuse injuries are more influenced by stress responses resulting from a lack of recovery (e.g., the repetition of micro-traumas).⁴⁴ However, on this point, most research into the associations between CAR quality and injury has focused on overuse injury.^{10,20} For instance, Pensaard et al.⁴⁴ indicated that players who have

communication difficulties with their coach may under-report pain and emerging injuries to avoid aggravating the conflict, which may lead to long-term overuse injuries. Considering these elements, future studies are encouraged to use a multidimensional injury measurement method, including indicators of incidence, type (e.g., overuse or acute injuries), and/or severity (e.g., duration of unavailability).³¹ This type of measurement would provide a more complete perspective on the nature of the association between CAR quality and injury risk over time.⁴⁵

Finally, although this study is the first to provide evidence of temporal associations between CAR quality (in terms of closeness, commitment, and complementarity) and athletes' individual injury rate, it did not identify the mechanisms involved in this relationship. On this point, the stress-injury model⁷ suggests that athletes' injuries result from their stress response in challenging situations. More precisely, this model postulates that stress is at the heart of the mechanisms involved in athletes' injuries, particularly through undesirable impacts on some cognitive, physiological, and sensory processes.²⁶ For instance, athletes in stressful situations can present attentional deficits in peripheral and central vision.⁴³ In turn, these attentional disorders are likely to cause difficulties in reacting to dangerous environmental signals (e.g., an opponent who collides with the ball carrier),⁴⁶ and are thus potentially responsible for the incidence of injuries. On this point, Pensaard et al.⁴⁴ suggested that an athlete's poor or conflictual relationship with their coach could be considered an important psychosocial stressor, and this phenomenon could be particularly marked in the context of intensive practice. In this context, athletes must cope with several psychosocial demands (e.g., the high expectations of coaches toward athletes in terms of performance and the pressure to perform consistently), which could represent an important source of stress for athletes.⁴⁷ Being confronted with high psychosocial demands on a daily basis is likely to generate high levels of stress in athletes, which in turn could increase their vulnerability to injury.⁷ Thus, it may be suggested that a poor CAR quality increases athletes' stress levels, which may account for the association with injury risk. Based on these propositions, future studies are needed to explore the potential mediating role of stress in the association between the evolution of CAR quality and injury risk.

Conclusion

This study provides new information concerning the psychosocial antecedents of injury risk in the sport science literature. Precisely, the results suggest that athletes who experience a deterioration in their relationship with their coach over time are likely to get more often injured. By highlighting explicit associations between the CAR quality and athletes' individual injury rate, the present

study highlights the need to adopt a systemic approach to better understand the occurrence and prevention of athlete injury. From a practical point of view, this study highlights the importance of developing and maintaining a high-quality CAR (e.g., through the elaboration of coaching education programs) to optimize athlete development and performance. On this point, the COMPASS model could be a particularly interesting resource for coaches to investigate in order to develop and/or maintain the quality of the CAR over time. For instance, the “openness” strategy, corresponding to establishing a climate of free and open communication, in which athletes feel free to talk and disclose their feelings and emotions, could be an important practical implication for coaches to develop/maintain the CAR quality, and minimize the risk of injury.

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Authors' contribution

VR contributed in the design of the study, the data collection and data analysis, and the interpretation of results. DT contributed in the design of the study, data analysis, and the interpretation of results. All authors contributed to the manuscript writing. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Consent to participate

A written consent form summarizing the aim of the study, and confirming that participation was voluntary and that they could withdraw at any time by informing the researchers, was given to all participants and their parents before the beginning of the study.

Consent for publication

An informed consent to publication has been obtained from the athletes and their parents. All data have been anonymized.

Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical considerations


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Note

1. The previous individual injury rate was calculated in the same way as the athletes' individual injury rate during the season by considering the number of training days the athlete was injured and the number of training sessions before the first measurement time.

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