

Diffusion and adoption of the Long-Term Athlete Development model among Canadian coaches

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Abstract

The aim of the present study was to document the process of Long-term Athlete Development (LTAD) adoption by Canadian sport coaches, and to identify predictors of: 1) their attitude and intention to adopt such a social innovation, and 2) their LTAD adoption level. Using Rogers' innovation diffusion theory, a survey of 499 Canadian coaches was conducted to identify the factors associated with three variables: coaches' attitude towards LTAD, intention to adopt LTAD, and LTAD adoption status. 279 (56%)(35.4 ± 12.1 years) of them knew LTAD and filled out the entire questionnaire. Perceived knowledge of LTAD, its trialability, observability, intention to adopt, coaches' certification level, and organisational support were the best predictors of LTAD model adoption level in coaching' practice ($R^2=0.579$, $F_{9,184}=28.32$, $p<0.001$). Coaches in late-developing sports declared having greater knowledge of LTAD, more capacity for its implementation, and lower perceived complexity of application.

Key words: diffusion of innovation; coaching; athlete development; social innovation; sports; coaching expertise

Introduction

Many models have been developed to help countries, sport organizations, and coaches prepare athletes to reach their full potential and to remain active after their sport career. In Canada, one of these approaches, named the long-term athlete development (LTAD) model of Balyi et al. (2005) was integrated in the sport system in 2005, after the adoption of *Canadian Sport Policy* recommendations in 2002 (Canadian Heritage, 2002).

LTAD is built on the scientific principles of growth, development, and skill acquisition (Bompa, 1995; Ford et al., 2011). Its approach suggests seven stages of development: (a) Active Start (0-6 years old), (b) FUNDamental (6-9 years old), (c) Learn to Train (8-12 years old), (d) Train to Train (11-16 years old), (e) Train to Compete (15-23 years old), (f) Train to Win (18+ years old), and (g) Active for Life (athletes and participants 12+ years old) (Canadian Sport for Life, 2017). The LTAD model was introduced as general and sport-specific version. Since its integration, 98.2% of the Canadian National Sport Organizations funded by the federal government have adapted LTAD to the

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reality of their sport field and athletes (Sport Canada, 2015). *Canadian Sport for Life* (2017) defines LTAD as "...a multistage training, competition and recovery pathway guiding an individual's experience in sport and physical activity from infancy through all phases of adulthood." Integration of such a model in Canadian coaching practice represents a paradigm change for most coaches (Lachance, 2014; Norris, 2010). **Canadian coaches were informed about LTAD during their National Coaching Certification Program (NCCP) course (Banack et al., 2012; Demers et al., 2006) or in continuing education courses.** Although this framework was better known from the Canadian experience, it is often less known that it had been adopted and tested simultaneously in the UK with Sports Coach UK/Sport England in 2004 and Irish Sport (Duffy et al., 2003). More international sport-specific examples are from the USA for ice hockey (USA Hockey, 2019), swimming in Portugal (Costa et al., 2021) and the United Kingdom until 2018 (Lang & Light, 2010). It is also suggested as the developmental approach by some sport federations like World Rugby (2021).

The intent of our study is to help understand the process of adoption of new guidelines by coaches in general. Also compared are LTAD adoption and implementation by coaches in different sports, providing some clues about the LTAD adoption process. We believe that studying Canadian coaches' experience with LTAD may help understand the adoption process of this framework but also contribute to the understanding of the adoption and implementation processes of social innovations in sport.

Since LTAD can be considered a complex social innovation, Rogers' *Diffusion of innovation theory* served as our conceptual framework. Social innovation is defined as "... the process of inventing, securing support for, and implementing novel solutions to social needs and problems" (Phills et al., 2008). All practitioners do not spontaneously accept such social innovations, or any other innovations; if they do, endorsement and implementation occur at different

paces (Rogers, 2003). **According to the theory, five attributes influence an individual to adopt or dismiss an innovation in this specific case: (a) the comparative advantage of LTAD in their current situation; (b) LTAD's compatibility with the coach's own values, past experiences, or actual needs; (c) complexity of LTAD, i.e. the degree to which it is perceived as easy or difficult to comprehend; (d) trialability of LTAD, i.e. the ability of individuals to experiment it, and (e) observability of LTAD, i.e. meaning an individual's ability to observe its claimed effects.** Many facilitators and barriers, subjective and objective, may influence the rate of innovation adoption and, eventually, implementation. Rogers' theory has helped to explain the process of innovation adoption in specific domains of sport science, such as exercise program evaluation (Westhoff & Hopman-Rock, 2002), sport management (Newell & Swan, 1995), and sport equipment adoption (Schreier et al., 2007). In the present study, the diffusion of innovation theory was used to help understand how coaches moved from their initial knowledge of LTAD toward its adoption and implementation in their practice (Rogers, 2003). In the process leading to innovation adoption, coaches would become persuaded to adopt its perceived positive attributes when they are interested and actively seek knowledge or specifics about LTAD (Rogers, 2003).

The aim of the present study was to document the process of LTAD adoption by Canadian coaches. More specifically, its objectives were to identify predictors of (1) their attitude and intention to adopt LTAD, and (2) their LTAD adoption level. **The potential predictors were the Rogers' theory attributes linked to LTAD (comparative advantage, compatibility, complexity, trialability and observability). Coaches' and their coaching environment's characteristics were then correlated with their attitude, intention, and adoption level of LTAD. Given the sufficient number of participants in some sports (figure skating, gymnastics, cross-country skiing, soccer and ice hockey) we were then able to compare different sports on their**

perceptions on LTAD, according to the attributes of the theory of innovation.

Materials and Methods

Participants

Seventy-five (75) of the initial 574 respondents were removed because of missing data, leaving 499 coaches, of which 220 did not answer Part 2 of the questionnaire since they indicated that they had no knowledge of the LTAD model. Nevertheless, we compared coaches aware of LTAD with those not aware to bring out possible distinctive personal or professional characteristics. The LTAD-aware participants ($n=279$) who filled out the entire questionnaire were 17 to 73 years old (35.4 ± 12.1 years), with 11.4 ± 8.9 years of experience in coaching. The sample was further grouped into different sports represented by 30 respondents or more (for statistical power reasons), and questionnaire results were analysed accordingly: soccer ($n=116$), ice hockey ($n=43$), figure skating ($n=49$), gymnastics ($n=50$) and cross-country skiing ($n=36$). Fifteen coaches were involved in both soccer and ice hockey, explaining the total of 294 (i.e. $279+15$) statistical pseudo-participants for this part of the study.

Questionnaire

We conducted an online survey on a sample of Canadian coaches, intended to help understand the process of LTAD adoption and implementation. The questionnaire was designed as based on Rogers' *Theory of diffusion of innovations* (Rogers, 2003). It was built with two parts and was self-administered online through our institutional survey tool *Banque interactive de questions/Interactive questionnaire bank*. Question wordings are presented in the Dependent variables section, lower. The first part consisted of questions about personal and professional (coaching) characteristics as well as level of LTAD knowledge. The relevance and wording of the questions were

checked before use by various experts in the field of coaching. To assess **face and** content validity of the survey, five high level coaches, five National Sports Organization (NSO) managers, and five coaches from different sport disciplines were invited to complete the questionnaire while taking notes to judge the correctness and clarity of the items. These 15 stakeholders from various sport disciplines and regions of Quebec were asked to comment on the overall understanding of the questions put to coaches (face validity). Face validity is important to judge if the tool assesses the concept it is supposed to measure, and refers to how items are to be interpreted by the intended audience (i.e., coaches) who will complete the questionnaire. They were invited to voice their ideas on possible important points that were not raised by the authors in the initial questionnaire (content validity). We added an expert in psychometry to our research (LL) to make the final adjustments to the procedure and contents for completing the questionnaire.

The survey was advertised to coaches by national, provincial and regional sport organisations. It was made available in both French and English. Participants who were familiar with LTAD also responded to Part 2, which was designed to document potential predictors of LTAD adoption based on Rogers' *Theory of diffusion of innovations*. Our study was approved by the institutional Ethics Committee of the Université du Québec à Trois-Rivières, and participants had to complete a consent form prior to the completion of the questionnaire.

Dependent variables

Three dependent variables were assessed: 1) coaches' attitude towards LTAD, 2) their intention to adopt LTAD, and 3) their LTAD adoption status. Attitude towards LTAD was estimated by the question: "Are you in favor of implementing LTAD in your sport? 1 = not at all; 2 = a little; 3 = moderately; 4 = pretty much; 5 = completely; 6 = don't know". Intention to adopt LTAD was measured by the question: "In the near

future, do you intend to include LTAD principles in your training plan? 1 = not at all; 2 = a little; 3 = moderately; 4 = pretty much; 5 = completely; 6 = don't know". The adoption status of LTAD "by coaches" was measured by this question: "Regarding LTAD, what statement corresponds best to your situation? 1 = don't know LTAD; 2 = know LTAD; 3 = interested in adopting LTAD; 4 = experienced some LTAD principles; 5 = adopted many of its planned principles; 6 = included most of its principles in my practice".

Independent (predictor) variables

Potential predictors of dependent variables were demographics and related to the *Diffusion of innovations* model. Demographics were coach's age, spoken language, years of coaching experience, coaching level, education level completed, type of sport, highest NCCP level achieved, and work regime (full or part-time). Variables related to the *Diffusion of innovations model* were: 1) respondent's self-perceived level of innovativeness and knowledge of LTAD, 2) perceived LTAD attributes: relative advantages, complexity, compatibility, observability, trialability (Rogers, 2003), and organisational support (Greenhalgh et al., 2004). Relative advantage was the level of perception that an innovation is an improvement over the idea or program it is supposed to replace. Compatibility referred to the perception that innovation is consistent with the present values, experiences and needs of potential adopters. Complexity was the level of perception that an innovation is complex and difficult to implement, while observability was the potential of an innovation to readily display its benefits. Trialability was the potential of an innovation to be tested. Perceived organizational support was defined as the capacity of an organization and some of its key stakeholders to support "the adoption of innovation by individuals in organizations," making adoption more likely (Greenhalgh et al., 2004).

Statistical analysis

When appropriate, scale and subscale consistency was assessed by Cronbach's alpha (SPSS 24.0): internal consistency was considered acceptable if alpha was ≥ 0.70 (Burns & Grove, 2001). Our data series, intended to identify predictors of attitudes, adoption intention and adoption level by correlational methods, derived mostly from Likert-type scales and displayed awkward or irregular distributions, thus compromising the use of Spearman rho or Pearson r coefficients. Instead, Kendall's τ (tau) coefficient for truly ordinal data was first obtained and then converted to equivalent Pearson r values according to Kendall's approximation formula: $r \approx \sin(\pi \cdot \tau / 2)$ (Kendall, 1970). A few mean-to-mean comparisons were made as per the Mann-Whitney U procedure. Chi-square tests were performed to identify differences between sports. The relative influence of each predictor was assessed by linear regression analysis. Differences between coaches who declared having no knowledge of LTAD vs. those with knowledge were verified by Student's t test or chi squared test, where indicated.

Results

Differences between coaches knowing or not knowing LTAD

Number of years of coaching experience was significantly higher among male coaches who knew LTAD (*a little* and *moderately*) vs. those who did not (12.74 ± 9.79 vs. 9.73 ± 7.04 years, respectively, $p=0.05$). There were no differences in coaching experience among female coaches between those knowing vs. not knowing LTAD. More coaches who knew LTAD vs. those who did not (79.9% vs. 59.7%) undertook continuing education activities during the previous 2 years ($\chi^2=15.37$, $df=1$, $p<0.001$). Similarly, they evaluated themselves as being more competent ($U=15718$, $p<0.001$) and reported higher education levels ($U=17678.5$; $p=0.002$). At the moment of the

survey, coaches with a better knowledge of LTAD were more numerous in the multisport coaching category ($\chi^2=5.876$, $df=1$, $p<0.05$).

Prediction of attitude and intention to adopt LTAD

Analysis indicated that the questions (3 each) on perceived knowledge and perceived advantage of LTAD showed strong consistency (Cronbach's alpha of 0.85 and 0.81, respectively). Attitude toward LTAD was best predicted with perceived relative advantage ($r=0.727$),

compatibility ($r=0.652$), perceived LTAD knowledge ($r=0.327$), trialability ($r=0.384$) and coaches' self-reported level of innovativeness (i.e., habit of taking coaching update courses) ($r=0.440$) (all $p<0.01$). Multiple regression for attitude yielded $R^2=0.480$ ($F_{5,190}$, $p<0.001$). Male gender was significantly associated with positive attitude towards LTAD ($r=0.204$; $p<0.05$), but was not retained by the regression equation, modulated by the fact that males were more often involved in coaching late development sports than female coaches.

The strongest prediction model for intention to adopt

Table 1. Coaches' characteristics

		Males (n=291)		Females (n=203)	
		Knew LTAD	Did not know LTAD	Knew LTAD	Did not know LTAD
Age (years)		38.67±12.04	39.51±11.10	30.92±11.75	31.57±12.08
Coaching (years)		12.74±9.79*	9.73±7.04	10.63±8.75	9.57±8.58
First language	French	142	75	115	65
	English	62	12	16	7
NCCP level completed	1	44	33	59	35
	2	67	30	42	26
	3	60	18	20	5
	4 and 5	16	0	9	1
Continuing education during the last 2 years	Yes	159	47	108	48
	No	44	40	23	24
Work status	Full-time	13	61	21	12
	Part-time	59	105	93	48
Position	Head coach	127	48	57	26
	Assistant coach	32	15	28	8
Salary	Paid	89	28	24	58
	Volunteer	61	36	12	22
Club environment	Urban	107	47	55	28
	Rural	96	40	73	44
Highest degree obtained	Physical education/kinesiology	75	12	32	12
	Education	8	1	14	7
	Other university	59	36	25	19
	Technical college	27	17	39	20
	High school	16	15	13	10
Type of sport (specialization)	Early	4	3	50	33
	Late	190	82	79	36
Number of sports coached	Multisport**	45	8	25	2
	One sport	183	54	124	52

* $p<0.05$ (t-test) for male coaches only; ** $p<0.05$ (Chi square test) for male coaches only. NCCP is for National Coaching Certification Program

LTAD in coaching practice included positive predictors. Knowledge of LTAD ($r=0.682$), perceived advantage ($r=0.590$), coaches' innovativeness ($r=0.414$) and trialability ($r=0.566$) were retained by regression analysis. Attitude toward the model ($r=0.641$), perceived compatibility ($r=0.613$) and gender ($r=0.303$) were all significantly ($p<0.01$) individually related to intention to adopt but were deemed redundant and put aside by the regression analysis.

Prediction of LTAD adoption level

Predictors of coaches actually adopting the LTAD model in their coaching practice were perceived knowledge index ($r=0.791$), coaching certification level ($r=0.454$), LTAD trialability ($r=0.633$), observability (0.620), organisational support ($r=0.521$) and intention to adopt LTAD ($r=0.671$) (all $p<0.001$). The corresponding multiple regression model with these predictors gave $R^2=0.579$, $F_{9,184}=28.32$, $p<0.001$. Considering estimated correlations of attitude and intention ($r=0.641$), attitude and adoption ($r=0.328$), intention and adoption ($r=0.671$), partial correlations showed that attitude added nothing to help predict adoption when intention was kept constant, whereas partialling out attitude affected (minimally) the predictive power of intention. A tentative multiple linear regression model for adoption supported this conclusion: intention alone brought about a R^2 of 0.295,

compared to 0.294, when the variable attitude was added.

Comparisons between sports

Cross-country skiing coaches had the highest perception of LTAD knowledge (fair to good 61.1%), while the percentages among figure skating and gymnastics coaches were 18.4% and 10,0% respectively (Table 2, $\chi^2=41.47$, $df=8$, $p<0.001$). Fairly good to good perceived capacity to implement LTAD followed the same trend, being highest among cross-country skiing (69.5%), soccer (56.2%) and ice hockey (50%) coaches, respectively (Table 3, $\chi^2=17.31$, $df=8$, $p=0.027$). However, only 30% and 26.6% of gymnastics and figure skating coaches respectively declared the same capacity to apply LTAD principles in their training. Again, in the same vein, cross-country skiing coaches were only 4.3% likely to view LTAD implementation as rather complex or complex, compared to more than 20% of all other coaches studied, but the difference was not significant (Table 4, $\chi^2=14.41$, $df=8$, $p=0.072$). Coaches identified some organisational constraints, but no significant differences were observed between various sports. Cross-examination of Tables 2, 3 and 4 indicates clearly negative associations between perceived complexity of LTAD implementation on the one hand vs. perceived knowledge of and capacity to implement LTAD, on the other hand.

Table 2. Coaches' perception of LTAD knowledge according to sport

	Soccer	Figure skating	Ice hockey	XC skiing	Gymnastics
Not at all	28.3% (32)	14.3% (7)	27.9% (12)	13.9% (5)	34.0% (17)
Somewhat	15.0% (17)	22.4% (11)	16.3% (7)	11.1% (4)	18.0% (9)
Average	18.6% (21)	38.8% (19)	18.6% (8)	8.3% (3)	26.0% (13)
Quite well	9.7% (11)	8.2% (4)	16.3% (7)	38.9% (14)	10.0% (5)
Absolutely	18.6% (21)	10.2% (5)	20.9% (9)	22.2% (8)	0% (0)
Did not know LTAD existed	9.7% (11)	6.1% (3)	0% (0)	5.6% (2)	12.0% (6)
% (N total)	100% (113)	100% (49)	100% (43)	100% (36)	100% (50)

Chi square (χ^2) =41.468, $df=8$, $p<0.001$: Gym < Soccer < Figure skating < Hockey < Cross-country skiing

Table 3. Perceived capacity to implement LTAD according to sport

	Soccer	Figure skating	Ice hockey	XC skiing	Gymnastics
Not at all	21.1% (12)	3.8% (1)	15.4% (4)	13.0% (3)	0% (0)
Somewhat	28.1% (16)	23.1% (6)	23.1% (6)	43.5% (10)	30.0% (6)
Average	19.3% (11)	46.2% (12)	38.5% (10)	34.8% (8)	35.0% (7)
Quite well	22.8% (13)	15.4% (4)	7.7% (2)	0% (0)	20.0% (4)
Absolutely	3.5% (2)	11.5% (3)	15.4% (4)	4.3% (1)	5.0% (1)
% (N total)	100% (54)	100% (26)	100% (26)	100% (22)	100% (18)

Chi square (chi2) =17.308, df=8, $p=0.027$: Gymnastics = Figure skating < Ice hockey < Soccer < Cross-country skiing

Table 4. Perceived complexity of LTAD implementation in sport (% of total N)

	Soccer	Figure skating	Ice hockey	XC skiing	Gymnastics
Not at all	1.8% (1)	6.7% (2)	10.7% (3)	4.3% (1)	10.0% (2)
Somewhat	7.5% (10)	30.0% (9)	7.1% (2)	4.3% (1)	15.0% (3)
Average	21.1% (12)	36.7% (11)	32.1% (9)	21.7% (5)	45.0% (9)
Quite well	21.1% (12)	23.3% (7)	35.7% (10)	56.5% (13)	30.0% (6)
Absolutely	5.1% (20)	3.3% (1)	14.3% (4)	13.0% (3)	0% (0)
% (N total)	100% (55)	100% (30)	100% (28)	100% (23)	100% (20)

Chi square (chi2) =14.413, df=8, $p=0.072$: Cross-country skiing < Soccer = Ice hockey < Figure skating < Gymnastics

Discussion

We first point out the differences between the groups, that is, between coaches who knew LTAD to varying degrees and those who did not, and then examine the first group to identify significant predictors of attitude and intent to adopt LTAD as well as predictors of the level of adoption of LTAD by Canadian coaches. Finally, we discuss differences between certain sports wherein enough participants filled out the questionnaire.

Differences between coaches knowing or not knowing LTAD

Coaches who did not know LTAD could not be included in the remaining part of the survey since they were not qualified to answer questions about LTAD adoption and implementation. However, their comparative personal and professional characteristics could yield useful information for coaches' education.

Indeed, some differences appeared between those who knew LTAD and those who did not. Male coaches with knowledge of LTAD were more experienced, with a significant seniority difference of 3.01 years; no such difference was found in female coaches. In their study sample of high-performance coaches involved with junior athletes in various sports, McKeown and Ball (2013) observed that coaches at this level had relatively good knowledge of different athlete development models. Only 4% of their sample had no knowledge of Balyi's LTAD, compared to 41.3% in our sample. The difference from our results may be explained by our sample, which included a higher proportion of coaches with beginner certification levels.

In addition, we noted that multisport coaches were more likely to be knowledgeable of LTAD. Being active in more than one sport federation may help coaches as they are more likely to be exposed to a sport federation that diffuses information on LTAD. Indeed, coaches

were informed about LTAD during their NCCP course (Banack et al., 2012; Demers et al., 2006) and in continuing education courses. Banack et al. (2012) determined that NCCP courses were efficient in transmitting LTAD knowledge in cross-country skiing coaches. Indeed, when we analysed data on sports including enough respondents, cross-country skiing coaches reported the highest level of LTAD knowledge, the best perceived capacity to implement it, and the lowest level of perceived complexity as compared to other sports considered. This was not surprising since cross-country skiing was one of the first sport federations to endorse LTAD and adapt its generic version to its own field, in 2007. Furthermore, cross-country skiing is known as a late development sport, which is compatible with LTAD principles.

The same rationale can explain why coaches engaged more often in continuing education were also more likely to know LTAD. However, one should be careful with this interpretation since knowing LTAD theory following coaching education activities may not necessarily translate into concrete actions in the field (Banack et al., 2012; Demers, Woodburn, & Savard, 2006). As suggested by van Kooten (2016) for judo – a sport with many traditions –, coaches come back from their seminar full of good intentions, only to return to traditional practice schemes which proved relatively successful (van Kooten, 2016). Indeed, this author even recommends return of the Canadian sport system to the old paradigm of financing sports that performed better. However, coaches interviewed by Beaudoin et al. (2015) considered that short-term financing was still predominant and noticed that financing short-term results was the main barrier to implementing LTAD in their respective sport.

The observation that higher education level by coaches increases the likelihood of knowing LTAD may be explained by the fact that LTAD is taught in some university curricula, as reported in a previous qualitative study (Beaudoin et al., 2015). Indeed, coaches with a physical education or kinesiology (n=92) academic

background scored higher on perceived base knowledge of LTAD than coaches with a degree in another specialty (n=187) (4.05 vs. 3.47, U=5,933, p<0.001).

Prediction of positive attitude and intention to adopt LTAD

The positive attitude of coaches toward LTAD was best predicted by perceived relative advantage and compatibility of LTAD, and by their knowledge of the model, LTAD trialability, and by their self-reported level of innovativeness as evaluated by their habit of continued education. Indeed, a positive and constructive attitude toward innovations can be developed in coach education programs, as suggested by Banack et al. (2012). Such coaching education activities would be warranted to demonstrate or help coaches discover the relative advantage and compatibility of LTAD with their own values and their athletes' needs. Recently, the Canadian Coaching Association made continuing education compulsory. This may facilitate the transmission of information and change attitudes towards coaching innovations.

Intention of coaches to adopt LTAD in their coaching practice was best predicted by a model that included: 1) perceived advantage, 2) perceived knowledge level of the model, 3) coach's self-reported level of innovativeness (i.e., the habit of taking coaching update courses), and 4) LTAD trialability. These results, analysed through the "*theory of innovation diffusion*," indicate that two attributes (perceived advantage, trialability) of an innovation have a strong influence on the intention to adopt it (Rogers, 2003). In our study, however, predictors of the intention to adopt LTAD were also two coach's characteristics and not only attributes of LTAD. Innovativeness is a personal characteristic that may be difficult to change but might be boosted with incentives to participate in continuing education. That was observed in nurse practitioners where graduate level education, years of experience as chief nursing officer and leadership course completion

were shown to increase innovativeness and innovation adoption (Clement-O'Brien et al., 2011). If coaches cannot necessarily acquire an innovative personality, they will at least be in touch with coaching novelties discussed in the seminars. That perceived advantage, a proven predictor, is consistent with Rogers' theory. When coaches see some relative advantages of LTAD vs. the superseded paradigm, they are tempted to adopt the new model. Indeed, in the qualitative study by Beaudoin *et al.* (2015), coaches mentioned many advantages, among which long-term vision, reference to developmental stages of athletes to plan training, and the creation of a common language with other stakeholders that were appealing to them (Beaudoin et al., 2015).

We observed that being a male coach correlated more than being female with intention to adopt LTAD. The reason may rest in the high number of women in early development sports, like gymnastics or figure skating, which are less compatible with LTAD, a context that abates the relevance of LTAD. Indeed, 50.5% of women coaches in our sample were in early specialisation sports (53 early vs. 52 late), in contrast to 4.2% of men (7 early vs. 159 late) ($\chi^2=78.51$, $df=1$, $p<0.001$). This low compatibility with early development sport increased the level of complexity perceived by coaches in figure skating and gymnastics (Table 4).

Prediction of LTAD adoption level

The following items best predicted the adoption level of the LTAD model in coaches' practice: 1) perceived knowledge index of the model, 2) coaching certification level, 3) LTAD trialability, 4) LTAD observability, 5) intention to adopt LTAD, and 6) perceived organizational support.

Perceived knowledge of LTAD remains influential for its adoption, as it does for attitude and intention to adopt. Therefore, the challenge is to nurture coaches' capacity to develop LTAD within their coaching programs and reinforce the importance of coaching

education to help coaches in implementing novel practices in general. In the few research reports published on LTAD, it has been mentioned that knowledge of LTAD theory has to be transferred and operationalized in a practical context which, while not easy to achieve (Black & Holt, 2009), is possible – as shown in cross-country skiing (Banack et al., 2012). Furthermore, in their qualitative study (Beaudoin et al., 2015, p.15), coaches identified specific areas of knowledge about LTAD that needed clarification: "...comprehension of the transition between development stages, methods to estimate athletes' stages, and identification of 'windows of opportunity' or critical periods" are subjects that may be relevant for better coverage in coaching education. In the same qualitative study of adoption/implementation, coaches indicated that they applied parts of the model piecewise instead of striving to implement the whole program (Beaudoin et al., 2015). Furthermore, if there were elements that they felt less knowledgeable about, they would choose to avoid them. As of now, no available evidence indicates that the complete model will meet its promises since no trial of the entire LTAD pathway has been completed (Ford et al., 2009).

The relation of coaching certification level to LTAD adoption level we observed may be explained by the same principles as those linking participation in coaching certification update activities (one type of innovativeness) with attitude and intention to adopt LTAD. Coaching certification courses through each level may increase knowledge and may foster innovativeness. In turn, the same applies to innovativeness, which is a predictor of attitude and intention to adopt. This is definitively an area to consider when promoting new approaches in sport coaching.

Trialability and observability were found to be good predictors of LTAD adoption. As mentioned by coaches in a previous qualitative study (Beaudoin et al., 2015), it is possible to experience some parts of LTAD and observe short-term effects on athletes. Again, this

suggests that, for coaching education in particular, hands-on experience may be a good way to help coaches adopt and implement LTAD. The positive contribution of coaching certification level to the prediction of LTAD adoption could be the result of more exposure to workshops or interaction with other coaches and clubs using components of the LTAD, as shown by trialability as a predictor of adoption. This is coherent with the literature which indicates the important role of trialability, as demonstrated by the adoption of *Lean Systems Thinking* in hospitals (Hayes et al., 2015). Is it possible to generalise this to other coaching innovations? Our results warrant further investigation of the question.

As mentioned earlier, results showing that male coaches had more favorable attitudes, higher intention and adoption levels than their female colleagues may be ascribed to the higher proportion of female coaches (41.9% of female vs. 3.9% in male coaches) involved in sports requiring early specialisation (e.g., gymnastics and figure skating). Our analyses also indicate that, although attitude may be linked significantly to intention to adopt LTAD, it adds nothing to reinforce the relationship between intention and adoption, as stated in the Results section. Another more daring explanation would be that highly qualified coaches, employed by large organisations, are encouraged to look for innovative approaches and even ordered to adopt promising programs, such as the LTAD model. It may explain why, in our sample, there was a significant and strong association between intention to adopt LTAD and level of adoption, notwithstanding coaches' attitude towards the program. This hypothesis has yet to be explored.

Interestingly, organisational support (Greenhalgh *et al.*, 2004) was a significant predictor of adoption level. The positive association between support and adoption level demonstrates that, when sport systems surrounding coaches support LTAD adoption (or any other innovation), they may help in adoption or, eventually, sustain implementation. This was a recurrent theme in

the findings of Beaudoin *et al.* (2015). Lack of support from the sport system was mainly attributed to organisational structures limiting LTAD adoption and implementation. Persistence of a system that emphasizes short-term results in competitions, while paradoxically asking to adopt and implement a long-term vision, sends contradictory messages to many coaches (Beaudoin *et al.*, 2015). Financing of sport is often operated on a yearly basis. Therefore, when coaches perceive that their club or federation supports them, they are more prone to adopt the proposed changes. As for the officials of provincial and territorial sport organisations, they indicate that LTAD implementation is hampered by a lack of funding as well as a shortage of human resources (Sutcliffe Group Incorporated, 2016). In a comparative study on the management of elite judo systems between South Africa, England and the Netherlands, strong influence of funding and resources was also clearly perceived as a major determinant for enabling performance pathways (Nolte *et al.*, 2017).

Differences between sports

We compared sports documented on at least 30 respondents and found differences. Coaches from a late development sport (cross-country skiing) manifested higher perception of knowledge, lower level of complexity and better perceived capacity to implement LTAD in their coaching practice. On the other hand, coaches in two early development sports had lower scores on these questions. Soccer and hockey scored between these two extremes. These results suggest that the LTAD agenda may be more compatible with late than with early development sports.

Study limitations

One of the limits of our study is that we relied solely on the reported perception of coaches. Therefore, we can report no objective data on the level and quality of adoption or implementation. As observed in reforms of all kinds, it may take some time before complete

implementation of the LTAD model can be achieved, if at all. On the other hand, coaches may find that only some parts of the model are pertinent and can be applied in their environment, while discarding other parts of LTAD. As mentioned by Chor *et al.* (2015, p. 568), “Indiscriminate adoption is not always an ideal outcome.” Reasons may justify non-adoption or partial adoption of LTAD, as seen in a qualitative analysis of LTAD adoption and implementation by Beaudoin *et al.* (2015). Similar “clinical guidelines” in the context of sport have seldom been studied. Similar complex changes have, however, been investigated in the health domain, particularly for the implementation of new clinical guidelines for nurses (Kapoor *et al.*, 2014). Citing the implementation model of Kapoor *et al.* (2014), based on nursing studies, two dynamic elements may be suggested for the development of sport coaching innovations: 1) the capacity of coaches to change norms, roles, and materials as well as increase access to cognitive resources, and 2) the potential of coaches to embrace changes, depending on their individual intention and shared commitment to apply them. Although our project concerned solely LTAD adoption, we believe that our conclusions pertain to other social innovations related to sport coaching. Finally, there is a need for sport specific studies about LTAD. As an example, there are data about LTAD and swimming where the volume of training was questioned (Lang & Light, 2010). In cross-country skiing, Frankish *et al.* (2012) found that LTAD implementation is conditioned by the structure of the club in which it is adopted. As a last limitation, Rogers’ diffusion of innovation theory has a focus on the individual and therefore neglect social factors (e.g. media and sociocultural context).

Conclusion and practical recommendations

To increase coaches’ attitude towards LTAD and intention to adopt it as well as their effective LTAD

adoption, the first step is probably to increase their knowledge of the model. This is applicable to any other innovation. Even though progress in the knowledge of LTAD was perceived by Canadian provincial and territorial sport organisations (PSTO), a lack of knowledge of LTAD was considered as a barrier to its implementation by 37% vs. 46% respectively for 2009 and 2016 (Kapoor *et al.*, 2014, p. 42): there is obviously some room to increase LTAD knowledge in coaches. Providing opportunities of practical coaching education may be a good way to positively influence intention to adopt, since taking coaching update courses is a predictor of adoption as well as trialability. Perception of knowledge and ability to apply principles of LTAD show significant and consistent differences between various sports. These differences may be explained by a questionable relevance of long-term development of expertise in disciplines requiring early vs. late development.

Even though a recent study has concluded that coaches from different countries (Australia, Netherlands, Portugal, Sweden, UK, USA) all face a huge challenge to integrate innovative approaches to their coaching practices (Stone *et al.*, 2020), our conclusion and practical recommendations should be contextualized to other cultures of sport and coaching. There is a need for comparative studies to verify how such social innovation are adopted and implemented in different international coaching communities.

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Authors' Declarations

The authors report no conflicts of interest. XXX at the moment of performing the research. She is now retired.

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