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Research article

Reliability and Validity of the Inline Skating Skill Test

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Abstract
This study aimed to examine the reliability and validity of the inline skating skill test. Based on previous skating experience forty-two skaters (26 female and 16 male) were randomized into two groups (competitive level vs. recreational level). They performed the test four times, with a recovery time of 45 minutes between sessions. Prior to testing, the participants rated their skating skill using a scale from 1 to 10. The protocol included performance time measurement through a course, combining different skating techniques. Trivial changes in performance time between the repeated sessions were determined in both competitive females/males and recreational females/males (-1.7% [95% CI: -5.8–2.6%] – 2.2% [95% CI: 0.0–4.5%]). In all four subgroups, the skill test had a low mean within-individual variation (1.6% [95% CI: 1.2–2.4%] – 2.7% [95% CI: 2.1–4.0%]) and high mean inter-session correlation (ICC = 0.97 [95% CI: 0.92–0.99] – 0.99 [95% CI: 0.98–1.00]). The comparison of detected typical errors and smallest worthwhile changes (calculated as standard deviations × 0.2) revealed that the skill test was able to track changes in skaters' performances. Competitive-level skaters needed shorter time (24.4–26.4%, all $p < 0.01$) to complete the test in comparison to recreational-level skaters. Moreover, moderate correlation ($\rho = 0.80–0.82$; all $p < 0.01$) was observed between the participant's self-rating and achieved performance times. In conclusion, the proposed test is a reliable and valid method to evaluate inline skating skills in amateur competitive and recreational level skaters. Further studies are needed to evaluate the reproducibility of this skill test in different populations including elite inline skaters.

Key words: rollerblading technique, roller sport, typical error, sensitivity, discriminant validity.

Introduction

The roller sport or inline skating is a rapidly expanding sport governed by the International Federation of Roller Sports (FIRS, 2016). It is among rare sports that have equal participation of men and women (International Olympic Committee, 2013). Although researchers identified a high risk of injuries related to inline skating (Nguyen and Letts, 2001; Tan et al., 2001), more than 50 million people worldwide practice this sport (International Olympic Committee, 2013). This is not surprising considering that numerous studies showed inline skating to have positive effects on cardiovascular health (Melanson et al., 1996, Orepic et al., 2014) and postural control (Muehlbauer et al., 2013; Taube et al., 2010). Moreover, it has been shown that inline skating helps to maintain specific abilities during off-season in complementary sports (de Boer et al., 1987; Crawford and Holt, 1991; Carroll et al., 1993; Duquette, 2000; Kroll et al., 2003; Stoggl et al., 2008), and in general enhances physical fitness in athletes (Martinez et al., 1993; Wallick et al., 1995). However, in order to become competent in this sport, long-term systematic training is required. In the early stages it is important to adjust to the unusual underfoot media (wheels), while in later stages skating technique becomes the focus (Powell and Svensson, 1998), which differs from the inborn pattern of human movement. Inline skating has thus been regarded as one of the most demanding sports in terms of motor skill requirement (Rinne et al., 2007). Due to frequent accelerations, starts and direction changes, which require rapid eccentric-concentric muscular efforts (Millet et al., 2003; Dellal et al., 2010), it depends predominately (~70%) on anaerobic metabolism (Reilly et al., 1990). However, the extent to which anaerobic processes participate in energy supply in inline skating depends on loading duration as well as on technical performance resulting in higher or lower mechanical efficiency of locomotion. Given the sport's popularity and significance of technical proficiency for both safe participation (Sherker and Cassell, 2002) and competitive performance (Parrington et al., 2013), it is surprising that studies evaluating specific skating skills are scarce. In order to optimize training, the contribution of generic motor abilities and specific skills in performance should be quantified and continuously monitored (Coutts and Cormack, 2004; Smith, 2003). While the literature offers a range of accepted methods for assessing generic motor abilities (Reiman and Manske, 2009), reproducible methods for testing specific skill in inline skaters are lacking. Our investigation aimed to examine the inter-session reliability and test the validity of the inline skating skill test in amateur skaters. Due to the mass popularity of roller sports, we performed the study on amateur inline skaters with the intention to aid coaches and skaters evaluate specific skater skills.

Methods

The study design encompassed two separate sections: the first evaluated the inline skating skill test's reliability, and the second assessed the test's validity. The test-retest reliability was evaluated comparing inline skaters' mean performances during subsequent skating sessions. The second measurement property – the construct validity – was in exercise science considered to be the extent to which a test discriminates between individuals of different standards (Ali et al., 2007). Therefore, the discriminative ability, and to an extent the construct validity of the

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proposed test, was examined comparing test outcomes of two groups categorized by different inline skating experience (amateur competitive vs. amateur recreational). Experience has already been identified as a good predictor of stride efficiency in inline skating performance (Parrington et al., 2013), hence it is a valid criteria for standard categorization. In order to add the discriminatory value and to supplement the hypothesis about the test's construct validity, individual test outcomes were correlated with the participants' inline skating skill self-ratings. This is a rational approach since some authors report that study participants can accurately evaluate their motor abilities (Sporis et al., 2011). The participants in the study, the inline skating skill test, as well as the experimental procedure and statistical analysis are described in detail in the next subsections.

Subjects

Forty-two adult female and male subjects who have been skating for at least two years were invited and volunteered in the study. All skaters, 26 female (age 23.3 ± 6.5 yrs, height 1.69 ± 0.07 cm, body mass 63.0 ± 6.5 kg) and 16 male (age 24.7 ± 10.0 yrs, height 1.78 ± 0.06 m; body mass 77.2 ± 9.9 kg) were recruited from the local skating association. They were members of an inline skating club or inline hockey club, which regularly participated in national amateur competitions. However, while some skaters participated both in training and in amateur competitions, others did not compete but regularly participated in training for health reasons, as described by Kokko et al. (2009). All skaters were interviewed before the study in order to check their eligibility, to establish two qualitative groups, and to ensure gender balance in both categories. During the interview they were asked about their skating experience and whether they had participated in competitions. Based on their responses, skaters were allocated to either competitive-level group (>2 years of amateur competition experience) or recreational-level group (no competition experience). Both groups had a similar distribution of males and females (~60% female vs. ~40% male) and did not differ in their sprint/agility performance. Inclusion criteria included at least 2 years of roller training experience, at least once weekly, the absence of illness, and no recent injury. The study was approved by the Ethics Committee of the University of Zagreb, School of Kinesiology. Each subject was individually informed about the nature, purpose and potential risks of the study, and written consent was obtained in compliance with the Declaration of Helsinki.

The Inline Skating Skill Test

The test was constructed to evaluate the individual's inline skating skill. It included techniques typical for roller sports such as start, circling and S-turning, push-off technique, acceleration, direction changes, and parallel technique. The following components of skills were tested: efficiency of pushing technique, coordinated direction changes and speed save. Thus, the performance time was used as an outcome measure of the evaluated inline skating test. The 83 m long testing course consisted of two tasks involving skating in 360° circles around markers (cones), three long accelerations using the push-off technique and each of those followed by parallel skating through the four cones positioned for slalom. As depicted in Figure 1, the goal was to skate the skating line linking the 1 × 1 m square start zone and 83 m distant finish line, as fast as possible. Beginning from the start first two circling cones were placed each on the 4 m distance with no deviation from the shortest path (i.e. the straight line that links the start and the finish). After circling the cones, the 11 m long runway preceded each of the three groups of slalom cones. The slalom cones were placed each at 4 m distance in a way that first two groups (wide slalom) had two cones on the shortest path and two cones 1.4 m deviating from the shortest path. The first group had two cones (2^{nd} and 3^{rd}) deviated to the right and the second group to the left side. The last group (narrow slalom) had the same 4 m distance between the cones but the entire group deviated from the shortest path in a manner that 1^{st} and 3^{rd} deviated 0.3 m to the right and 2^{nd} and 4^{th} to the left side, respectively. At the 6 m distance from the last slalom cone, the finish line was drawn and the timing gates were placed. The performance time from start to finish was recorded to the nearest 0.01 s by an electronic system (Newtest Powertimer, Finland, EU) using light barriers for speed-measurement. The subjects were instructed to skate as fast as they could, following the defined skating course and technical requirements. When

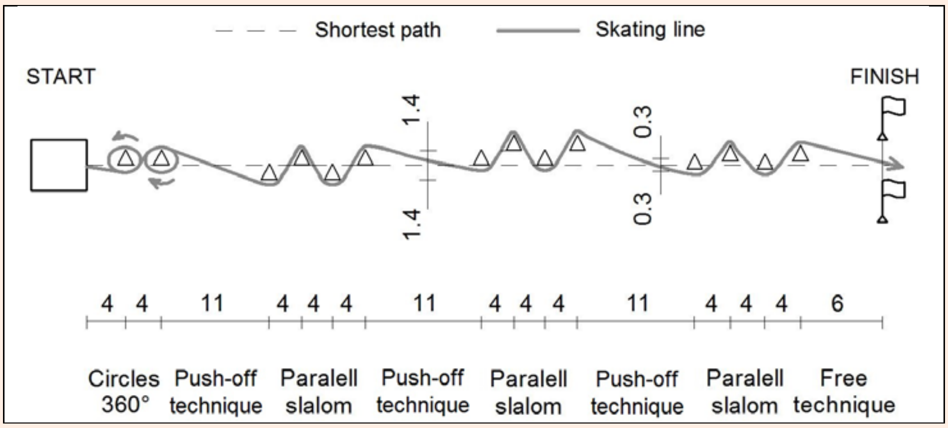

Figure 1. Layout of the inline skating skill test. All dimensions are expressed in meters.

skating circles, subjects were offered to choose the technique freely but were required to complete 360° of the circle with all wheels on the surface. They were taught not to cut over the placed cones but to skate around them. In case where instructions were not followed, the test was repeated after recovery time. Once in ready position, participants were permitted to start at self-selected time. Detailed explanation of testing procedures as well as performance control and time measurements were done by two examiners.

Experimental procedure

The experimental protocol consisted of a pre-examination and four repeated skating tests through courses, each followed by a 45 minute passive recovery. The measurements were performed during dry days on a flat asphalt-base. They were conducted during the daylight, on non-windy days with an average temperature of 18 ± 2.5° C. The subjects were asked to come at the testing field in groups of eight to ten participants. They were all equipped with protective gear and inline skates (Rollerblade^{TM} Macroblade 80 AluMens, Tecnica Group S.p.A., Inc., Italy) with aluminum frame 260 mm, 4 wheels 80 mm in diameter and hardness 82A, and smooth bearings SG7. Upon arrival, the subjects were informed about the testing procedure. The pre-examination consisted of a short questionnaire regarding personal data (age, height, body mass), self-evaluation of skating skills, and the sprint and the agility test. The subjects evaluated their skating skill on a scale from 1 to 10. As suggested by Mabe and West (1982) and in order to enhance the validity of self-assessment, subjects were told that the self-evaluation will be compared to test performance time (i.e. criterion measure; Athanasou, 2005); and also with other skater's time within the group (Martin et al., 2002). Only researcher knew this data. Prior to skating performance testing, a standardized 15-minute warm-up that included exercises for joint mobility, stretching, sprints and running with direction-change was completed. In order for this test to be successful it requires a certain level of sprint and direction change performance; hence, this variable was controlled using a 10 m sprint and agility tests to ensure that groups did not defer substantially. In order to minimize the learning effect, each subject was allowed to skate along the skating course twice before starting the test. The passive recovery lasted three minutes separating practice attempts and the measured tests. The order in which subjects performed the test was random but was unchanged during subsequent trials.

Statistical analysis

The software package Statistica for Windows 12.0 was used for statistical analysis of the obtained data and outcomes were reported as means and standard deviations. The statistical significance was set at $p < 0.05$. In order to make sure that the obtained data are normally distributed Kolmogorov-Smirnov test was applied. In compliance with suggestions made by Hopkins (2000) the reliability of the subsequent measurements was evaluated using systematic bias, within-individual variation and re-test correlation. Also, 95% confidence intervals were reported for all values representing the components of reliability. In order to gain the insight into the systematic bias, the differences in mean performance time between the four trials were determined by ANOVA for repeated measures. The relative reliability (i.e. between-individual variation) was evaluated using intra-class correlation coefficients while the typical error and the coefficients of variation were used to assess the absolute reliability (i.e. within-individual variation). To determine all measures of reliability between three consecutive pairs of tests (T2-T1, T3-T2, T4-T3), the spreadsheet made by Hopkins (2009) was employed. As proposed by Hopkins (2004), the practical usefulness of the test was evaluated by comparing typical errors of subsequent pairs of tests to the smallest worthwhile change in performance time across the tests. The smallest worthwhile changes in performance time across tests were expressed as a product of the between-subject standard deviation and default value 0.2 (i.e. typical small effect; Hopkins, 2004). Differences in test performance times between the two groups of skaters were compared by means of one-way ANOVA while Spearman's correlation coefficients (ρ) were applied to determine relations between skaters' self-evaluation and inline test outcomes for each trial.

Results

The mean reliability measures of the inline skating skill test are presented in the Table 1. The average time required to perform the test was less than 30 seconds. Trivial changes were recorded in both competitive (female -1.5–2.2%, male -0.7–0.1%) and recreational (female -1.0–1.4%; male -1.5–0.2%) subjects' mean performance time (i.e. no systematic bias) between three pairs of repeated tests. The within-individual variation expressed in raw data as a typical error ranged among tests from 0.16 to 0.33 s in female and 0.19 and 0.25 s in male competitive level skaters, as well as from 0.09 to 0.12 s in female and 0.16 and 0.20 s in male recreational level skaters. When expressed in percentages (i.e. as coefficient of variation), the absolute reliability of the performance results between subsequent measurements in competitive group ranged from 1.3% to 2.5% in females and from 1.4% to 1.7% in males. Within recreational level group, the coefficient of variation varied from 2.3% to 3.1% and from 1.7% to 2.1% in females and males, respectively. For each pair of tests, observed mean typical error was lower than the smallest worthwhile change given by SD × 0.2. Besides, the skill test had high mean inter-sessions correlations in both qualitative groups and corresponding female and male subgroups (Table 1).

Concerning discriminative ability of the test, one-way ANOVA confirmed differences in performance times between competitive-level group and recreational-level group (24.4–26.4%; all $p < 0.01$) during each of four tests. Likewise, the individual performance times in each of four tests decreased with an increase in self-reported proficiency. Spearman's correlation coefficients showed positive association ($\rho = 0.80$–0.82; all $p < 0.01$) between the self-evaluation at scale 1-10 and achieved outcomes in all tests.

Table 1. Reliability parameters of the inline skating skill test and the smallest worthwhile change in performance time of 4 trials

Group	n	T1 (s) mean (±SD)	T2-T1 (%) 95% CI	T3-T2 (%) 95% CI	T4-T3 (%) 95% CI	TEmean (s) 95% CI	CVmean (%) 95% CI	ICCmean 95% CI	SWC0.2(s) mean
CL female	10	25.1 (1.8)	1.5 (-5.2–2.4)	-1.7 (-5.8–2.6)	2.2 (0.0–4.5)	.25 (.18–.47)	2.1 (1.4–3.9)	.99 (.97–1.00)	.39
CL male	6	21.6 (1.7)	-.7 (-2.4–.9)	-.4 (-2.4–1.7)	.1 (-1.6–1.9)	.21 (.15–.32)	1.6 (1.2–2.4)	.97 (.92–0.99)	.34
RL female	16	33.0 (8.7)	-1.0 (-3.8–1.8)	1.4 (-1.6–4.6)	.4 (-1.8–2.7)	.10 (.08–.15)	2.7 (2.1–4.0)	.99 (.98–1.00)	1.86
RL male	10	26.0 (3.1)	.2 (-2.9–3.4)	-.5 (-3.1–2.2)	-1.5 (-3.9–1.0)	.17 (.13–.30)	1.9 (1.4–3.3)	.99 (.96–1.00)	.55

CL = Competitive level; RL = Recreational level; T1, T2 = Trial 1, Trial 2; T2-T1 = Change in the mean between Trial 2 and Trial 1; TE_{mean} = Mean typical error of three consecutive pairs of the test; CV_{mean} = Mean coefficients of variation of three consecutive pairs of the test; ICC_{mean} = Mean intra-class correlation coefficients of three consecutive pairs of the test; 95% CI = 95% Confidence interval; $SWC_{0.2}$ = Smallest worthwhile change given by standard deviation × 0.2

Discussion

This study demonstrated that the inline skating skill test adequately measures skills used in roller sports. Specifically, results showed that the test consistently measures performance time across repeated testing sessions in both female and male skaters. In addition, it proved to be sufficiently sensitive to detect changes in performance times of both recreational level and competitive level skaters. In line with reported experience and self-perceived skating skill, competitive level skaters outperformed the test better in comparison to recreational level skaters, thus supporting the discriminative validity of applied test.

Reliability of the Inline Skating Skill Test

When evaluating sporting performance, reliable data collection requires testing consistency across a number of trials (Hopkins, 2000; Lockie et al., 2013). We evaluated the skaters' consistency in skating performance time and consequently their rank within the group across four subsequent tests. No significant differences (-1.7% [95% CI: -5.8–2.6%] – 2.2% [95% CI: 0.0–4.5%]) were observed in the mean performance times between testing sessions in all groups, suggesting no habituation to the test. To the best of our knowledge, no information regarding the inline skating skill test is available in the literature. Hence, obtained results are discussed in the context of the studies evaluating similar tests of acceleration and direction change performances. Inter-class correlation coefficients (>0.70) and coefficients of variation (<5%) detected for applied inline skating test meet the reliability standards of previously evaluated agility tests (Lockie et al., 2013; Spasic et al., 2015; Wilkinson et al., 2009). The mean inter-class correlation coefficients in competitive subgroups (female r = 0.99 and male r = 0.97) for evaluated skill test represent strong retests correlation and excellent relative reliability between tests. Recently observed inter-class correlation coefficients for agility tests ranged between notably lower values (r = 0.68; 95% CI: 0.55–0.78) found by Raya et al. (2013) in army service members and slightly lower values (r = 0.91–0.93) reported by Lockie et al. (2013) and Spasic et al. (2015) in Australian footballers and handball players, respectively. In addition, high relative reliability of evaluated inline skating test was supplemented by low mean within-individual variation (1.6–2.7%), thus indicating a very good absolute reliability. The mean coefficient of variation for the present skill test is consistent with those obtained for IAR agility performances of squash and soccer players (1.8%; Wilkinson et al., 2009), and Australian footballers (2.5%; Lockie et al., 2013). Considering the performance length of skating test (26.9±7.3 s vs. ~14.8 s reported for IAR by Wilkinson et al., 2009) and specific technical requirements that may have increased the noise (i.e. typical error), a low within-individual variation observed within this study becomes even more significant.

Nevertheless, the satisfactory reliability and the usefulness of any skill test should be considered before its application in practical and/or research purposes. Human motor skills are often subject to different interventions, aiming to improve performance. To assure reliability of a measured signal while testing particular skills over time, it is important that detected noise during testing does not conceal observed change. Therefore, we compared the mean typical error of three pairs of trials (Table 1) with the smallest worthwhile change given by SD × 0.2 (Table 1). According to the rating proposed by Hopkins (2004), our comparison suggests that the test is able to track performance changes at a satisfactory (i.e. "OK") level in female and male amateur competitive skaters and at a "Good" level in both groups of recreational skaters. Additionally, it would be important to see if the present test also tracks performance changes in elite competitive inline skaters. At this point, there is no data available concerning variability of performance in roller sports' competitions. One could generalize the data published for ice speed skating with the inline skating test due to technical similarities between the sports (Crawford and Holt, 1991; de Boer et al., 1987). Recently, Noordhof et al. (2015) reported within-athlete variability between speed skating races in elite senior and junior athletes (0.6% and 0.9% respectively). Such variability would require the test to detect ~1% differences in performance in order to track changes in performance of elite competitors. In comparison, within-athlete variability for the present test in amateur competitive-level male inline skaters ranged from 1.4% to 1.7%. Assuming that variation in elite competitive performance of speed skating and inline skating is similar, above level of variability is likely to be less discriminative for tracking changes in performance of elite inline skaters unless we average the performance times of many trials (~10) as proposed by Hopkins et al., (2009). However, existing differences between ice speed skating and roller sports make the above comparison at this point speculative. From the perspective of inline skating practice, the proposed test is able to track changes in an amateur skaters' skill.

Construct validity of the Inline Skating Skill Test

In the practice of sport coaching, the construct validity was determined as the ability of the test to discriminate between performers of different qualitative categories (National Coaching Foundation, 1995). Besides, the construct (i.e. the test outcome) was positively associated with the "component of fitness known to aid the tested performance" (Lockie et al., 2013; Wilkinson et al., 2009). To evaluate the construct validity of the applied test, we first tested differences between competitive-level *vs.* recreational-level skaters, and secondly, established correlation between subjects' self-evaluation of inline skating skill and their test results. It followed that the mean performance time was considerably shorter (~25%, $p < 0.01$) in skaters who reported participation in amateur competition when compared to skaters reporting participation only in inline skating trainings. Moreover, moderate correlations ($\rho \geq 0.80$; $p < 0.01$) were established between high self-evaluation scores and performance times indicating that used skill test discriminated individuals who self-evaluated various levels of skating skill. These results are in agreement with those reported by Parrington et al. (2013), who determined greater stride-width in advanced in contrast to the intermediate skaters, as well as poorer recovery, lower stride-width-recovery, and higher stride rate in novice skaters in comparison to the intermediate and advanced level skaters. In particular, second analysis and its outcome is similar to study of Wilkinson et al. (2009) where two trainers classified players within the group, thus establishing the base for ranking association with the test outcomes. The correlation of slightly lower magnitude ($\rho = 0.77$) between test outcomes and players' ranking was interpreted as "moderate", and the performance test recommended as valid for screening purpose. In the above context, the obtained results support the presumption about construct validity of applied test in amateur level skating.

Practical implications of the study

High participation rate in both roller sports and inline skating activities other than merely competitive (see Introduction) indicate that the evaluated test could have wider use. The skill test is designed primary to help coaches and athletes assess specific inline skating skills. Since this test was found to be reliable and valid, it could be applied to examine effects of different training strategies or diet interventions, and could optimize training in amateur roller sports. In addition, the test proved to be suitable for both roller sport competitors and inline skaters participating only in training. Hence, it might be useful in monitoring effects of both training aimed at maintaining specific skills in complementary sport athletes and programmes intended at building inline skating skill in recreationists. In particular, this skill test might be useful "dry" environment tool in predicting success in ice skating (Janot et al., 2015). Finally, authors accentuated that data on technical proficiency might not only enhance the performance but also indirectly reduce the risk of injuries in skating (Renger, 1994; Sherker and Cassell, 2002). Thus, the information obtained by the inline skating test could be used to endure safe participation in inline skating.

Limitations

Among the study's limitations, two deserve particular attention. First, the present findings are established on data collected from amateur skaters. Thus, the ability of evaluated test to track performance changes in top level inline skaters cannot be established from our data. Additional studies are needed to prove its practical usefulness in elite level skaters. Nevertheless, the test is valid and reproducible for a number of amateur skaters participating in national roller sport competitions and recreational inline skating programmes. Second, 'trial-to-trial' protocol may be observed as a disadvantage since the retest on the same day leads to higher reliability in comparison to retests on separate days (Mikulic et al., 2009). However, data on detected reliability among four trials 45 minutes apart were satisfactory high and even small reduction in observed values would still suggest good standard of reliability.

Conclusion

The obtained results confirmed that the applied test is a reliable and valid method in evaluation of specific inline skating skill among amateur skaters. Moreover, the test is suitable for tracking changes in performance of amateur competitive and recreational level skaters. Finally, the results support the routine use of the proposed skill test for research or/and the practical setting aimed to evaluate inline skating skills in amateur competitive and recreational level skaters. The utility of proposed test with other populations including top-level skaters needs to be further investigated.

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Key points

- Study evaluated the reliability and construct validity of a newly developed inline skating skill test.
- Evaluated test is a first protocol designed to assess specific inline skating skill.
- Two groups of amateur skaters with different skating proficiency repeated the skill test in four separate occasions.
- The results suggest that evaluated test is reliable and valid to evaluate inline skating skill in amateur skaters.

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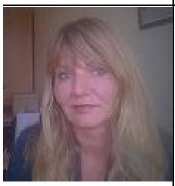

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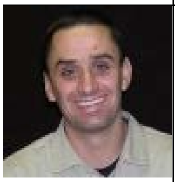

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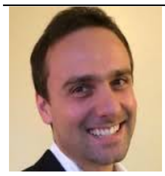

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