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Hand preference patterns in expert basketball players: Interrelations between basketball-specific and everyday life behavior

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ABSTRACT

In the present study we examined the interrelation of everyday life handedness and hand preference in basketball, as an area of expertise that requires individuals being proficient with both their non-dominant and dominant hand. A secondary aim was to elucidate the link between basketball-specific practice, hand preference in basketball and everyday life handedness. Therefore, 176 expert basketball players self-reported their hand preference for activities of daily living and for basketball-specific behavior as well as details about their basketball-specific history via questionnaire. We found that compared to the general population the one-hand bias was significantly reduced for both everyday life and basketball-specific hand preference (i.e., a higher prevalence of mixed-handed individuals), and that both concepts were significantly related. Moreover, only preference scores for lay-up and dribbling skills were significantly related to measures of basketball-specific practice. Consequently, training-induced modulations of lateral preference seem to be very specific to only a few basketball-specific skills, and do not generalize to other skills within the domain of basketball nor do they extend into everyday life handedness. The results are discussed in terms of their relevance regarding theories of handedness and their practical implications for the sport of basketball.

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1. Introduction

In general, hand preference in human is lateralized with a strong bias towards the right side. This can be inferred from large cohort studies (e.g., Bryden, 1977; Gilbert & Wysocki, 1992; Perelle & Ehrmann, 1994; Raymond & Pontier, 2004), in which individuals were asked to report their preferred hand for activities of daily living (e.g., writing, throwing a ball or hammering). Reviewing hand preference patterns in a large number of individuals (i.e., over one million) from 81 international samples (Bryden, 1977; Gilbert & Wysocki, 1992; Perelle & Ehrmann, 1994), Raymond and Pontier (2004) found 85–93% right-handed and 7–15% left-handed individuals. Variations were explained by cultural differences. Gabbard and Iteya (1996) provided a trichotomous distribution of handedness in adults with around 84% right-handed, 6% left-handed and 10% mixed-handed individuals. Since half of the mixed-handed individuals tended to be more right-handed, while the other half tended to be more left-handed, this distribution is within the ranges of western societies shown by other studies (see Raymond & Pontier, 2004). Although it is commonly accepted that the hand bias is determined by genetics (Annett, 2002; Corballis, 1997; McManus, 2002) along with cerebral asymmetries (e.g., Goodale, 1988; Knecht, 2000; Schluter, Krams, Rushworth, & Passingham, 2001), little is known about its potential adaptability in response to lateralized or bilateral practice (e.g., Mikheev, Mohrb, Afanasiev, Landis, & Thut, 2002; Stöckel & Weigelt, 2012; Teixeira & Okazaki, 2007; Teixeira, de Oliveira, Romano, & Correa, 2011) and the interrelation between hand preference for activities of daily living (subsequently referred to as everyday life handedness) and hand preference in areas of expertise that require individuals being as proficient with their non-dominant as with their dominant hand.

In a recent study, Stöckel and Weigelt (2012) found that in competition professional basketball players use their non-dominant hand more frequently (up to 26.3% of all ball-contacts in a game) and with greater success than players from lower competitive levels. Likewise, the use of the dominant hand was reduced to 48.8% in professional players as compared to amateurs (59.2%). In particular, the higher non-dominant hand use of professional players compared to amateurs appeared for dribbling actions (47.0% versus 19.9%) and to a much lesser extent for passing (11.5% versus 4.4%) and catching actions (8.6% versus 2.0%). They assumed that the extensive basketball-specific practice (i.e., training of the dominant and non-dominant hand) accounts for the reduced one-hand bias (i.e., the strong tendency to prefer either the right or the left hand) in professional basketball players (i.e., in terms of a training-induced plasticity of handedness). However, in the absence of any measures of players' everyday life handedness and basketball history their assumption is disputable for at least two reasons: First, it is possible that individuals with a less pronounced hand preference in everyday life activities have an advantage over strongly lateralized individuals to advance to higher leagues in basketball (cf. Bale & Scholes, 1986). Second, the amounts of basketball-specific practice and/ or experience are not essentially related to players' competitive level (e.g., the basketball-specific experience of young talents playing in higher leagues can be substantially lower than that of older amateurs). In their view the higher prevalence of mixed-handed individuals (based on everyday life handedness) among professional basketball players shown elsewhere (cf. Bale & Scholes, 1986), would be ascribed to training-induced changes of lateral preference that extend into everyday life handedness. However, to date there is no evidence that domain-specific bilateral practice modulates hand preference for activities of daily living.

In that regard, the purpose of the present study was to examine whether the reduced one-hand bias in professional basketball players is specific to the domain of basketball or separate skills thereof, or if it depends on (or extends into) everyday life handedness. A secondary aim was to elucidate the role of basketball-specific practice (i.e., training on both the dominant and non-dominant hand) on hand preference in basketball and everyday life handedness. Therefore, 176 male basketball players from the three highest German leagues self-reported their hand preference for activities of daily living (i.e., everyday life handedness) via the Edinburgh Handedness Inventory (EHI; Oldfield, 1971) and their basketball-specific hand preference as well as details about their basketball-specific history via the Basketball Laterality Questionnaire (BLQ, a modified version of the Aberdeen Football Laterality Questionnaire, Carey et al., 2009). We hypothesized that professional basketball players would report a reduced one-hand bias for both, hand preference in basketball (cf. Stöckel & Weigelt, 2012) and

everyday life handedness (cf. Bale & Scholes, 1986) as compared to the general population (cf. Gabbard & Iteya, 1996). Both constructs are expected to be interrelated at least to some extent due to the genetic predisposition of handedness (cf. Annett, 2002; Corballis, 1997; McManus, 2002). With regard to the notion that extensive amounts of bilateral (or lateralized) practice lead to modulations of lateral preference (e.g., Mikheev et al., 2002; Stöckel & Weigelt, 2012; Teixeira & Okazaki, 2007; Teixeira et al., 2011), we hypothesized that one hand preference in basketball decreases with increasing amounts of basketball-specific practice (as measured by years of coached practice and self-reported estimates of ever achieved non-dominant hand practice). Taken together, the interrelations between basketball-specific hand preference, everyday life handedness and basketball-specific practice are expected to indicate whether an advanced selection process or training-induced changes of lateral preference account for the reduced one-hand bias in professional basketball players.

2. Material and methods

2.1. Sample

Hand preference patterns were assessed from 176 male basketball players. The minimum requirement to admit players to the sample was that they were currently playing in one of the three highest German leagues (i.e., Bundesliga, Pro A and Pro B). This resulted in a sample of basketball players between 17 and 36 years old (mean: 24.05 ± 4.64 years) reporting between 5 and 29 years (mean: 11.90 ± 5.05 years) of coached practice in a basketball club. 69 of these athletes played in the third, 61 in the second, and 46 played in the first German basketball league (including four athletes who already played in the NBA). Concerning player positions, 76 were identified as guards, 58 as forwards and 35 as centers (seven participants did not indicate their playing position). Questionnaires were distributed to the athletes by the coaches of the respective teams on a voluntary basis.

2.2. Self-assessment tools

Questionnaires on hand preference in basketball and on hand preference for activities of daily living were distributed to the players before their regular practice sessions either in German or English, and had to be filled out on their own immediately. The first part of the questionnaire consisted of six questions to assess demographic data of the participants, and to re-check whether the subjects fulfilled the minimum requirements to be admitted to the sample (e.g., sex, age, player position, current competitive level). In the second part, the 10-item Edinburgh Handedness Inventory (EHI; Oldfield, 1971) was included for the assessment of hand preference for activities of daily living. The handedness score for those activities was computed as suggested by Oldfield (1971). The resulting EHI score (between −100 and 100) was translated into a trichotomous measure of handedness with scores below −40 indicating left-handedness, between −40 and 40 indicating mixed-handedness (i.e., ambidextrous subjects) and scores above 40 indicating right-handedness. This was done to also identify mixed-handed or weakly lateralized individuals, instead of the strict separation of right- and left-handed players as proposed by the original dichotomous measure (Oldfield, 1971). The third part of the questionnaire was a modified version of the Aberdeen Football Laterality Questionnaire (AFLQ; Carey et al., 2009). Since the AFLQ pertains to foot preference in football-related behaviors, for the aim of the present study the AFLQ was modified in a manner in which subjects were asked for their hand preference in basketball-related behaviors. Structure and content for the Basketball Laterality Questionnaire (BLQ) were adopted from the AFLQ. Questions of the BLQ can be found in the annex. Most importantly, the BLQ comprises a part with questions on hand preference for 12 basketball-related skills (see Appendix questions 5.–16.), for which respondents have to decide on a 7 point scale which hand they prefer to use for the respective behavior from "always left" (1), "equal use" (4) to "always right" (7). For each skill the deviation of these raw scores from 4 (i.e., the middle of the 7-point scale indicating equal hand use) was used as the primary outcome (basketball laterality score, BLS) as these measures indicate the degree of hand use independent of the dichotomous distribution of handedness (cf. Carey et al., 2001). Additionally, mimicking Carey et al. (2009, p. 653) the average score (using the

raw scores on the 7-point likert scale) across the 12 questions on the basketball-related skills was translated into a trichotomous measure of basketball-specific hand preference with scores up to 3 indicating left hand preference, scores above 3 and below 5 no preference (i.e., 3.01–4.99) and scores of 5 and higher indicating right hand preference.

2.3. Data analysis

In order to test for the interrelation between everyday life and basketball-specific hand preference, we correlated the average individual raw scores of the BLQ and EHI scores. Chi-square tests were conducted to assess whether the distributions of basketball-specific hand preference (i.e., based on BLQ) and everyday life handedness (i.e., based on EHI) were different from handedness in the general population (i.e., based on the distribution provided by Gabbard & Iteya, 1996). In order to identify similarities in self-reported hand preference underlying the twelve basketball-related skills measured with the BLQ, we employed principal component analysis (PCA) with an oblique rotation (Promax) – as with regard to handedness there is no reason to assume that the factors are completely independent. Scree plot (Cattell, 1966) and Kaiser Criterion (Kaiser, 1960) were used to decide what factors to retain. Individual loadings of 0.4 or greater were used in factor designation. Based on the principal components structure, three subscales were determined a posteriori of which the sum scores were subjected to a multivariate analysis of variances (MANOVA) as within-group factors with everyday life Handedness (right, mixed, left) and Playing Position (guard, forward, center) as two between-group factors to examine differences in self-reported hand preference between the subscales of the BLQ, players' everyday life handedness (based on the EHI), and playing positions. For any significant main or interaction effects, post hoc pairwise comparisons using the Sidak adjustment were performed between any two given conditions (e.g., between right- and left-handed players). Data are reported as mean ± SEM. Last, we employed correlation statistics (Pearson) to identify potential interrelations between self-reported hand preference for each of the subscales of the BLQ, everyday life handedness (absolute EHI score), and two measures of basketball-specific practice (years of coached practice, and a rough estimate of ever achieved non-dominant hand practice.[1])

3. Results

Based on the EHI (Oldfield, 1971), the sample consisted of 73.1% right-handed, 10.3% left-handed and 16.6% mixed-handed individuals considering hand preference for activities of daily living. When the same population was asked for their hand preference in basketball-related behavior, based on the skills included in the BLQ, 76.0% reported a right-hand preference, 11.1% a left-hand preference, and 12.9% equal hand preference. Average individual raw scores of the BLQ were positively related to EHI scores ($r = .71$, $p < .001$). Both the distributions of everyday life handedness (based on the EHI), $\chi^2(2) = 25.68$, $p < .001$, and basketball-specific hand preference (based on BLQ), $\chi^2(2) = 10.55$, $p < .01$, of the present sample of basketball players differed from the general population (based on trichotomous handedness data from Gabbard & Iteya, 1996: 84% right-handed, 7% left-handed, 9% mixed-handed), especially due to the 10.9% and 8.0% lower rates of right-handed individuals in the sample of basketball players respectively.

In order to identify similarities in self-reported hand preference underlying the twelve basketball-related skills measured with the BLQ, we employed principal component analysis (PCA) with an oblique rotation (Promax). A total of $n = 171$ expert basketball players were included in PCA after list wise exclusion of missing values (i.e., five participants each with one or more missing answers on one of the questions). Kaiser–Meyer–Olkin measure of sampling adequacy (0.79) as well as Bartlett's Test of sphericity ($\chi^2(66) = 536.12$, $p < .001$) were satisfying to detect the factors with PCA (i.e., factorability can be assumed). Three factors emerged, each with an eigenvalue greater than 1, accounting for 55% of the total variance. As shown in Table 1, five of the skills had greatest factor coefficients (>0.4) on Factor I, accounting for 32% of the variance. Based on the included skills with greatest loadings, the first factor

[1] Estimates for non-dominant hand practice ranged from 0% to 50% ($M = 23.3\%$, $SD = 14.9\%$) with zero indicating that the player never practiced with the non-dominant hand and 50% indicating equal amounts of dominant and non-dominant hand practice.

Table 1
Rotated pattern matrix for hand preference in basketball-related skills from the BLQ.

Skill	Factor I [BLS_{LD}]	Factor II [BLS_{Shots}]	Factor III [BLS_{CP}]
Lay-up underhand	.81		
Lay-up overhand	.77		
Dribbling (no opponent)	.72		
Dribbling (1 on 1)	.71		
Short pass	.43		
3-Point shot		.75	
Free throw		.70	
Mid-distance shot		.63	
Long catch			.84
Short catch			.82
Long pass			.62
Steal			.53

Note: Factor loadings are sorted by size. Values <0.4 are suppressed. BLS = Basketball Laterality Score for lay-up and dribbling (LD), distance shots (Shots), catching and passing (CP).

can be called a construct of "lay-up and dribbling skills".[2] The sum score of the included skills will be later referred to as average basketball laterality score for lay-up and dribbling skills (BLS_{LD}). Three skills had greatest loadings on Factor II, accounting for 13% of the variance. Based on the included skills, this factor can be named a construct of "distance shots" (i.e., shooting actions from a distance over one meter). The sum score of the included skills will be later referred to as average basketball laterality score for distance shots (BLS_{Shots}). Finally, four skills had greatest loadings on Factor 3, accounting for 10% of the variance. Based on the included skills with greatest loadings, this factor can be described as a construct of "catching and passing skills", later referred to as BLS_{CP}.

In a second step sum scores of the three subscales of the BLQ were subjected to a MANOVA with BLS (BLS_{LD}, BLS_{Shots}, BLS_{CP}) as within-group factor and everyday life Handedness (right, mixed, left) and Playing Position (guard, forward, center) as two between-group factors. The analysis revealed a significant main effect for BLS, $F(2,310) = 218.53$, $p < .001$, $\eta^2 = .59$. Post hoc pairwise comparisons revealed the lowest deviation from self-reported equal hand use for the BLS_{LD} (1.01 ± .08) as compared to BLS_{CP} (1.29 ± .09; $p < .01$) and BLS_{Shots} (2.77 ± .04; $p < .001$); and the highest deviation score for BLS_{Shots} (both p's <.001) (cf. Fig. 1). Moreover, a main effect for Handedness, $F(2,155) = 4.14$, $p < .05$, $\eta^2 = .05$, yields at differences in hand preference between right-handed (1.77 ± .04), mixed-handed (1.45 ± .11) and left-handed individuals (1.85 ± .11) (cf. Fig. 1). Post hoc pairwise comparisons revealed the differences between right- and mixed-handed as well as between left- and mixed-handed individuals to be significant (both p's <.01). Last, the analysis revealed a significant interaction of BLS and Playing Position, $F(4,310) = 3.28$, $p < .05$, $\eta^2 = .04$. Post hoc pairwise comparisons revealed highest deviation scores for BLS_{Shots} compared to BLS_{LD} and BLS_{CP} for all playing positions (all p's <.001). Only in guards the deviation score for BLS_{LD} (0.83 ± .11) was significantly lower than for BLS_{CP} (1.27 ± .12). However, hand preference did not differ between the three playing positions for any of the three BLS subscales. The analyses revealed no other main or interaction effects.

To examine potential interrelations between hand preference in basketball (BLS subscales) and everyday life handedness (EHI scores) as well as the two measures of basketball-specific practice (years of coached practice, rough estimate of ever achieved non-dominant hand practice) we employed correlation analyses (Pearson). Raw correlations between these variables are presented in Table 2. As prior analyses revealed no differences between left- and right-handed players, absolute values of the EHI score were used for correlation statistics. Positive correlations were observed

[2] For reasons of consistency and as the item 'short pass' also loads to a quite similar extent on Factor III (0.34), Factor I was named based on the items with greatest loadings. However, 'short pass' will remain in Factor I for subsequent analyses as hand preference patterns for that skill seem to be more equal to lay-up and dribbling skills than other catching and passing skills.

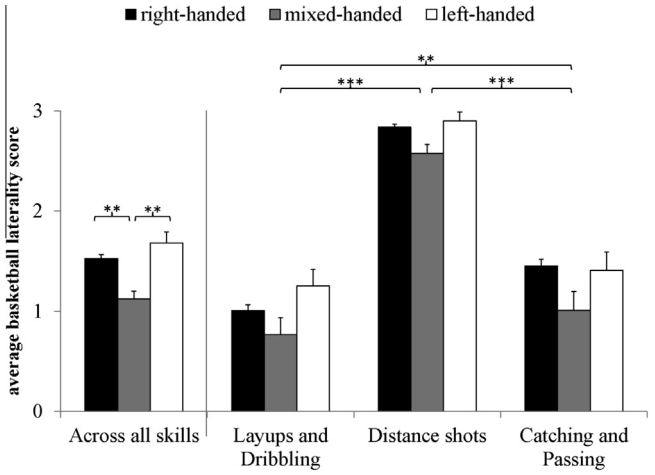

Fig. 1. Basketball laterality score (i.e., deviation from equal hand use) across all skills of the BLQ and for the three subscales identified with similar hand preference patterns compared between right-, mixed- and left-handed individuals based on everyday life handedness. Error bars indicate the SEM. Significant differences are highlighted with ** for $p < .01$ and *** for $p < .001$.

Table 2
Raw correlations among study measures of interest.

	BLS_{LD}	BLS_{Shots}	BLS_{CP}	|EHI score|	Coached practice
BLS_{LD}					
BLS_{Shots}	0.148				
BLS_{CP}	**0.520*****	0.142			
Absolute EHI score	**0.254****	**0.190***	**0.291*****		
Coached practice (years)	−0.029	0.010	0.069	−0.063	
Estimated non-dominant hand practice (%)	−**0.307*****	−0.052	−0.090	−0.062	−0.126

Note: Asterisks represent significance level of bivariate Pearson's correlation ($^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$; bold values). BLS = Basketball Laterality Score for lay-up and dribbling (LD), distance shots (Shots), catching and passing (CP). EHI = Edinburgh Handedness Inventory.

between BLS_{LD} and BLS_{CP} ($r = .520$, $p < .001$). BLS_{Shots} did not correlate with any of the other BLS subscales. Positive correlations were also observed between absolute EHI score and all three BLS subscales (all r's >.190, all p's <.05). However, absolute EHI score did not correlate with players' years of coached practice or the estimate of ever achieved non-dominant hand practice. Coached practice did not correlate with any of the other variables. Last, a negative correlation was observed between estimates of self-reported ever achieved non-dominant hand practice and BLS_{LD} (i.e., greater deviations from equal hand use for lay-up and dribbling skills when lower rates of non-dominant hand practice were reported, $r = -.307$, $p < .001$).

4. Discussion

The purpose of the present study was to examine whether the reduced one-hand bias in professional basketball players is specific to the domain of basketball or separate skills thereof, or if it depends on (or extends into) everyday life handedness. A secondary aim was to elucidate the role of basketball-specific practice (i.e., training on both the dominant and non-dominant hand) on hand preference in basketball and everyday life handedness as it has been suggested that "increasing amounts of basketball-specific practice can result in a modulation of lateral preference" (cf. Stöckel

& Weigelt, 2012, p. 1044). Therefore, 176 professional basketball players self-reported their everyday life handedness and their basketball-specific hand preference as well as details about their basketball-specific history via questionnaire.

In line with previous studies, we found that compared to the general population (cf. Gabbard & Iteya, 1996) the right-hand bias in professional basketball players was reduced for both hand preference in basketball (cf. Stöckel & Weigelt, 2012) and everyday life handedness (cf. Bale & Scholes, 1986). Translating the average raw score of self-reported hand preference across the twelve basketball-specific skills from the BLQ into a trichotomous measure of basketball-specific handedness resulted in 76.0% right-handed, 11.1% left-handed and 12.9% mixed-handed individuals.[3] A similar picture emerged for players' everyday life handedness with 73.1% right-handed, 10.3% left-handed and 16.6% mixed-handed individuals. Compared to the distribution of handedness in the general population (Gabbard & Iteya, 1996), in particular for everyday life handedness we found a 7.6% and 3.3% higher prevalence of mixed-handed and left-handed individuals among professional basketball players respectively. Interestingly, basketball-specific hand preference was strongly related to everyday life handedness, and did not differ between right- and left-handed players. Only mixed-handed individuals reported a higher equal hand use across all skills, although almost all players judged the relevance of being equally skilled with both hands to be very high for success in basketball (M = 6.01/7, SD = 1.08). Hence, the reduced one-hand bias of expert basketball players is not specific to the domain of basketball. It appears that, despite task-specific differences (e.g., distance shots versus lay-ups and dribblings), all dimensions of basketball-specific hand preference (i.e., including a high intra-individual variability between skills and subscales of the BLQ) are related to everyday life handedness. Accordingly, the higher prevalence of mixed-handed individuals among high-level basketball players might as well account for the reduced one side bias in professional basketball players as observed by Stöckel and Weigelt (2012).

This notion gets support from the finding that basketball-specific practice (i.e., deliberate practice with both the dominant and non-dominant hand as assessed by years of coached practice and a rough estimate of ever achieved non-dominant hand practice) is not related to everyday life handedness, and is only in part related to hand preference in basketball (i.e., the higher the self-reported rates of non-dominant hand practice the less lateralized are lay-up and dribbling skills). Hence, basketball-specific practice seems to have the potential to evoke task-specific modulations of hand preference for single skills (e.g., lay-up and dribbling skills), but the effects do not generalize to other skills within the domain of basketball nor do they extend into everyday life handedness. In contrast to previous studies (Mikheev et al., 2002; Teixeira & Okazaki, 2007), training-induced adaptations and/or modulations of lateral preference following basketball-specific practice seem to be very specific to the respective domain or just single tasks thereof. As professional basketball players have been shown to be as proficient with the non-dominant as with the dominant hand for passing and shooting skills (Stöckel & Weigelt, 2012), basketball-specific practice seems to affect skill but only marginally choice of hand (see Carey et al., 2009; Teixeira et al., 2011 for similar findings for foot preference in soccer players). This dissociation between skill and choice of hand contradicts the notion that manual preference evolves as a function of superior performance of one hand compared with the other (Bishop, 1989), however, it is in accordance with studies on foot preference in professional soccer players (Carey et al., 2009) and on hand preference following unilateral practice (Teixeira & Okazaki, 2007; Teixeira & Teixeira, 2007). From that, we argue that the bias in hand preference is an innate trait (Annett, 2002; Corballis, 1997; McManus, 2002) that is robust against extensive amounts of bilateral practice giving rise to the idea of a lateralized motor control system as a result of cerebral asymmetries (e.g., Goodale, 1988; Knecht, 2000; Sainburg, 2002; Schluter et al., 2001; Serrien, Ivry, & Swinnen, 2006). Intra-individual differences in hand preference between single tasks are rather subject to specific constraints, demands and affordances linked to the respective task.

[3] Validity of the BLQ to assess basketball-specific hand preference gets support from similar findings on actual hand use of professional basketball players (Stöckel & Weigelt, 2012). First, that study revealed a similar distribution of hand use across all ball contacts (73.0% right-handed, 3.2% left-handed and 23.8% mixed-handed individuals based on re-analyzed hand use data of 63 professionals). Second, they have shown as well that the dominant hand was used for all distance shots, lowest deviations from equal hand use emerged for dribblings (and shots close to the rim), and hand use did not differ between playing positions.

With regard to the domain of basketball, players of the present sample reported to prefer their dominant hand (as lead hand behind the ball) for virtually all shots from larger distances, whereas the lowest deviations from equal hand use were reported for layups (i.e., shooting directly at the basket) and dribblings followed by catching and passing skills. Here it is to note, that players are often forced by their opponents to use their non-dominant hand for layups, dribblings and passes in particular, and thus, the use of the non-dominant hand is often essential for success in certain situations. Therefore, basketball players are taught to use their non-dominant hand for these actions from early on (e.g., layups from the left side with the left hand and from the right side with the right hand). Hence, when the choice of effector can be made independently (e.g., free throws) and/or the task implies high dynamic demands (e.g., generation and dissipation of strength for three-point shots and long distance passes; cf. Sainburg, 2002), people revert to their more skilled, dominant hand. But when skills have to be performed in interaction with others and/or under high pressure (e.g., layups, dribblings, and short passes), where the choice of effector most often depends on the situation on the court (i.e., interaction with others), then the hand used is the one that is most proficient in the given situation.

In sum, our findings indicate that the reduced one-hand bias in professional basketball players, as has been recently demonstrated by Stöckel and Weigelt (2012), is *not* a specific adaptation of hand preference to the bilateral demands of the domain of basketball as both hand preference in basketball (cf. Stöckel & Weigelt, 2012) and everyday life handedness (cf. Bale & Scholes, 1986) are affected and both are interrelated. Our results indicate that mixed-handed individuals are overrepresented amongst professional basketball players (see also Bale & Scholes, 1986) and that the more pronounced equal hand use across all skills of these individuals (compared to left- and right-handed players) predominantly accounts for the reduced one-hand bias in professional basketball players – but *not* basketball-specific adaptations in hand preference (cf. Stöckel & Weigelt, 2012). In fact, training-induced modulations of lateral preference seem to be very specific to only a few basketball-specific skills (i.e., lay-up and dribbling skills), and do not generalize to other skills within the domain of basketball nor do they extend into everyday life handedness. Hence, it is more likely that the reduced one-hand bias in high-level basketball players can be ascribed to an advanced selection process with less lateralized individuals (i.e., mixed-handed individuals) being more likely to advance to higher competitive levels in basketball as being proficient with both hands seems to be an advantage in basketball (also see Bale & Scholes, 1986).

From an applied perspective these and previous results suggest that strongly lateralized individuals may be at a distinct disadvantage in basketball, as it is very likely that these players will use their dominant hand most of the time even in situations in which the non-dominant hand is most proficient. However, for the rare occasions they use their non-dominant hand, they might be as proficient with the non-dominant as with the dominant hand (cf. Stöckel & Weigelt, 2012). Therefore, both the EHI and the BLQ could be useful sources for talent identification in basketball. As the rough measures of basketball-specific practice of the present study are of limited inferential value regarding the potential adaptability of hand preference in response to bilateral practice, future studies should (a) employ longitudinal designs to confirm the low impact of basketball-specific practice on hand preference and actual hand use in basketball, and (b) conduct intervention-based experiments to examine whether hand preference in basketball can be modulated by restricting the choice of hand to the non-dominant hand in game-like play for a while, especially in strongly lateralized individuals.

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Appendix A.

Basketball Laterality Questionnaire (BLQ): Structure and contents were adopted from the Aberdeen Football Laterality Questionnaire (AFLQ; Carey et al., 2009) and modified to satisfy the specific characteristics of basketball.

1. How many years have you played organized team basketball?
2. How many of these years included coached practice/training by a coach, manager or player-manager?
3. Have you ever been encouraged by a coach/manager/player-manager to practice using your non-preferred hand? (Yes/No)
4. If yes, estimate what percentage rate of your (ever achieved) practice you actually were made to practice with your non-preferred hand.

5-16. Basketball-specific questions.
Which hand do you prefer for the following skills/ behavior?
(7-point Likert, 1 = Always left, 4 = Equal, 7 = Always right).
Free throw, overhand layup, underhand layup, mid-distance shot, three-point shot, unhindered and 1-on-1 dribbling, one-handed short and long pass, one-handed catch of a short and a long pass, steal.

17. How alike are your two hands in terms of shooting performance? (1 = Not at all alike, 7 = Extremely alike).
18. How important do you think "two-handedness" (e.g. being equally skilled with both hands) is for a skilled basketball player? (1 = Not at all important, 7 = Very important).

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