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Does momentum exist in women's top-league basketball in Iceland?

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Does momentum exist in women's top-league basketball in Iceland

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Abstract

Objectives: To determine if: (I) shot outcome is associated with the outcome of the previous shot, (II) if shot outcome is affected by performance variables of shots, and (III) if performance variables of shots are influenced by the previous shot outcome.
Methods: Shooting performance in 10 matches, 20 team performances, in the women's basketball top-division in Iceland analysed (n=128). Seven performance variables recorded for each shot. Chi square tests of independence determined if there was an influence of previous shot outcome on current shot outcome, and if different locations and comparing them in terms of percentage scored. Wilcoxon tests to compare how often each shot location was chosen after the previous shot was scored or missed. Wilcoxon and Friedmans tests used when analysing shot outcome with shot location. Wilcoxon and Friedman test to analyse shot outcome with the performance variables, and Wilcoxon tests to see the effect previous shots had on performance variables.
Results: Three of the 20 team performances showed significant association between shot outcome and previous shot outcome ($p<0,05$). Shot outcome did not significantly influence subsequent shot location ($p>0,05$). Significant association between performance variables and current shot outcome was detected ($p<0,05$) but no significant association found between the previous shot outcome and the performance variables for the current shot ($p>0,05$). The results did not favour any of the theoretical models of momentum over others.
Discussion: The lack of momentum in most performances may be explained by the lower shooting accuracy in the Icelandic top-division (fewer than 50% of 2 point attempts scored). Addressing shot location when studying momentum cannot be justified by the current findings. Performance variables significantly affect shot outcome, but previous shot outcome does not affect performance variables.

Keywords: Basketball, momentum, hot hand, streakiness, shot outcome

Ágrip

Markmið: Að ákvarða hvort: (I) útkoma fyrri skota hafi áhrif á næsta skot á eftir, (II) ef frammistöðubreytur hafi áhrif á útkomu skota, og (III) ef útkoma fyrri skota hafi áhrif á frammistöðubreytur í næsta skoti.
Aðferð: Skot úr 10 leikjum í efstu deild kvenna í körfubolta á Íslandi skoðuð (n=128). Gögn sjö frammistöðubreyta safnað úr hverjum leik fyrir hvert skot. Kí-kvaðrat próf (Chi square test of independence) notað til að ákvarða hvort útkoma fyrri skota hafi áhrif á næsta skot á eftir, einnig notað til að bera saman staðsetningu skota og prósentu af skoruðum körfum. Wilcoxon próf og Friedmans próf notuð til að ákvarða hvort útkoma fyrri skota hafi áhrif á staðsetningu næsta skots. Wilcoxon próf og Friedmans próf notuð til að skoða tengingu milli skota og frammistöðubreyta.
Niðurstöður: Þrjú lið sýndu merki um meðbyr (positive momentum) því marktækur munur fannst milli útkomu skota og útkomu fyrri skota ($p<0,05$). Útkoma skota hafði ekki marktæk áhrif á staðsetningu skota ($p>0,05$). Marktækur munur var milli frammistöðubreyta og skota ($p<0,05$) en enginn marktækur munur fannst milli útkomu fyrri skota og frammistöðubreyta ($p>0,05$). Niðustöðurnar styðja enga af þremur fræðilegu líkönunum um meðbyr og mótbyr fram yfir aðra.
Umræður: Skortur á meðbyr í flestum leikjunum gæti verið útskýrður með lélegri skotnýtingu í efstu deild kvenna í körfubolta (minna en 50% af 2 stiga skotum voru skoruð). Ekki er hægt að réttlæta með núverandi niðurstöðum að nota staðsetningu skota þegar meðbyr eða mótbyr (negative momentum) er rannsakaður. Frammistöðubreytur hafa áhrif á niðurstöðu skota en niðurstöður fyrri skota hefur ekki áhrif á frammistöðubreytur í næstu skotum.

Leitarorð: Körfubolti, meðbyr, mótbyr, hot hand, útkoma skota

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List of abbreviations

PM	Psychological momentum
BM	Behavioural momentum

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Introduction

In sports it is a common belief that "success breeds success and failure breeds failure" (Bar-Eli et al., 2006, p. 526). This is what research has termed as *momentum,* also known as *the hot hand* or *streakiness*. It is the belief that a performance of an athlete or a team is temporarily better than would be expected based on previous performances (Gilovich et al., 1985; Koehler & Conley, 2003). Momentum can both be used about a team winning or losing consecutive games or about a performance of an individual player or team within a game (Arkes & Martinez, 2011). There is a debate in the literature and to this day the question as to whether momentum does exist in sports or not remains unresolved (Bar-Eli et al., 2006).

Momentum in sports has been widely investigated either through a psychological approach (e.g., Vellerand et al., 1988; Taylor & Demick, 1994; Cornelius et al., 1997; Gernigon, 2010; Moesch & Apitzach, 2012; Iso-Ahola & Dotson, 2014) or a behavioural approach (e.g., Mace et al., 1992; Vergin, 2000; Koehler & Conley, 2003; Csapo & Raab, 2015a; Wanzek et al., 2012; Roberts & O'Donoghue, 2014; Redwood-Brown et al. 2017).

It has been suggested that momentum is a strong indicator of match outcomes in sports (e.g., Iso-Ahola & Mobily, 1980; Iso-Ahola & Blanchard, 1986; Weinberg & Jackson, 1989; Miller & Weinberg, 1991; Burke et al., 2003; Smisson et al., 2007; Wanzek et al., 2012). Taylor and Demick (1994) defined the term momentum as a multidimensional construct where different scenarios can cause changes in cognition, behaviour, and physiology, either positive or negative, which can lead to changes in performance and outcome of matches. In other words, positive momentum is when a success in performance influences future performance success, and negative momentum is when unsuccessful performance influences future unsuccessful performance (Taylor & Demick, 1994; Iso-Ahola & Dotson, 2014). Furthermore, positive momentum is the belief that a performance of an athlete or a team improves temporarily after a string of success (Koehler & Conley, 2003).

Athletes, coaches, sport commentators and media believe that momentum exists in sports and that it affects performance (Adler & Adler, 1978; Iso-Ahola & Blanchard, 1986; Perreault et al. 1998). This belief can affect the behaviour of players and coaches who believe that the phenomenon exists (Attali, 2013). Momentum is moreover commonly used to explain performance and even make predictions based on previous or ongoing performance of an

athlete or a team (Briki, 2017). According to Koehler and Conley (2003) the hot hand metaphor has always been most closely linked to basketball and commentators tend to use the term to describe the performance of players and teams during games. The hot hand term refers to the probability of a player making a successful basket after the previous shot was successful (Bar-Eli et al., 2006; Arkes & Martinez, 2011). It is therefore interesting to see if statistical analysis can support the theory of momentum, or the hot hand, in basketball.

It has been argued that it is not possible to detect momentum in basketball due to the nature of the sport. However, most of previous studies that have examined momentum in the sport have excluded the effect of defensive pressure to simplify the research (Csapo & Raab, 2015a). In this study we will include opposition disposition to see if it affects shot outcome, as defensive pressure is an important factor in basketball. Similar research has been done in netball (Roberts & O'Donoghue, 2014) and handball (Mortimer & Burt, 2014), using similar variables, and one in basketball to our knowledge (Csapo & Raab, 2014).

The aim of this study is to investigate the concept of momentum, using a behavioural approach, in Icelandic women's top-league basketball. There have been limited studies on momentum in women's basketball to this day in the world, and only two studies on the topic found (Wardrop 1999; Roane et al., 2004). No research has been done on momentum in any sport in Iceland to this day. However, Halldorsson (2016) did study why coaches use timeouts in handball which is a topic closely related to momentum. There is therefore definitely a gap in the research and an opportunity to study the topic in Icelandic women's basketball.

The three models of momentum in sports

Although the concept psychological momentum (PM) was first discussed in 1978 by Adler and Adler, the first conceptual model for it was the antecedents-consequences model introduced by Vallerand et al. (1988). The model states that the right combination of personal variables and situational variables will lead to the perception of PM (Cornelius et al. 1997). Furthermore, when there is a change in performance it is believed that PM is present. It is also suggested that PM might be the cause of the change in performance. The model states that the perception of PM "must be distinguished from its antecedents and performance consequences" (Vallerand et al., 1988, p. 92). However, recently it has been suggested that many PM variables are both determinants and consequences of PM states (Briki et al. 2012). The variables that have been suggested to influence PM, either independently or as a complex interaction, are internal, environmental, or social (Taylor & Demick, 1994). Examples of internal variables are

psychological states and fatigue. Examples of environmental factors are opponents and scoring, and examples of social variables are crowd influences and team cohesion.

A few years after Vallerand et al. (1988) introduced their model, Taylor and Demick (1994) proposed the multi-dimensional model. The model suggested that the development of momentum can be explained by a "momentum chain" (Taylor & Demick, 1994, p. 56). This momentum chain consists of six crucial elements: (a) precipitating event or events, (b) change in cognition, affect and physiology, (c) change in behaviour, (d) change in performance consistent with the above changes, (e) a contiguous and opposing change in the previous factors on the part of the opponent, and (f) a resultant change in the immediate outcome (Taylor & Demick, 1994, p. 56).

The third model of momentum, the projected performance model, was presented by Cornelius et al. (1997). It states that positive and negative PM are not the cause of performance changes but rather the results. The authors suggest that frequent changes in performance might just be normal variations around the average performance level but not necessarily positive and negative PM. This assumption makes people think if momentum does in fact exist.

The scientific world has these three alternative models of momentum. What we will find in this research might support one of these models and might challenge the others.

Psychological momentum

As mentioned earlier momentum is normally investigated through either a psychological approach or a behavioural approach. Although we will be using a behavioural approach in this study it is important to view previous research on both psychological and behavioural approaches. By doing so it will give a better and deeper understanding of the concept momentum.

Psychological momentum (PM) was first discussed by Adler and Adler (1978). It is a term used in sport psychology that captures positive or negative change in cognition, affect and behaviour in athletes, coaches, and fans as well as the relationship between success and future performance (Vallerand et al., 1988; Taylor & Demick, 1994; Jones & Harwood, 2008). Since then, several studies have tried to examine and explain the concept in sports (e.g., Forthofer, 1991; Stern & Morris, 1993; Cornelius et al., 1997; Perreault et al., 1998; Albert & Bennett, 2001; Gula & Raab, 2004; Gernigon et al., 2010; Csapo & Raab, 2015a). It is widely discussed in the literature but is however not well understood (Taylor & Demick, 1994).

PM was defined by Iso-Ahola and Mobily (1980) *"*as an added or gained psychological power that changes a person's view of him/herself or of others, or other's views of him/her and themselves*"* (p. 392). The term has been used to describe a change in the state of mind which enables athletes to perform better than is expected of them (Iso-Ahola & Dotson, 2014). Athletes, coaches, and sports commentators often perceive PM as a strong determinant of athletic performance, either successful or unsuccessful (Stanimirovic & Hanrahan, 2004). However, there is a debate in the literature if there is in fact a relationship between PM and sport performance (Redwood-Brown et al. 2017). Studies by Cornelius et al. (1997) and Jones and Harwood (2008) provide evidence that PM can predict performance outcome while a study by Koehler and Conley (2003**)** provides evidence against it. Despite this debate there is a strong belief that PM is a significant factor when it comes to success in sports (Redwood-Brown et al., 2017).

Cornelius et al. (1997) analysed PM using the antecedent-consequences model by Vallerand et al. (1988). The study contained 132 participants, aged 17 to 33 years old, from a university physical education class. The participants performed two rounds of free throw shooting between pairs of players. The psychological variables used were for example competitive state anxiety and self-confidence and the situational variables were winning and losing. The results suggested that the participants experienced PM and believed that their performance was influenced by it. Both situational variables and self-rating of performance significantly predicted perceptions of momentum but only the situational variables could significantly predict changes in performance. Another study examining the perception of PM was done by Jones and Harwood (2008) in team sport players. The study contained five university football players, playing at a senior amateur level at the time of the study, and had many years of experience playing competitive football. The study consisted of three phases of in-depth formal interviews, both semi-structured and unstructured, as well as comprehensive member check**.** The results showed that the participants used strategies to both develop and maintain positive PM. They also developed strategies to overcome negative PM**.** This could be an essential tool for athletes to overcome string of bad outcome and practice strategies to change negative PM into positive PM.

Gernigon et al. (2010) analysed the influence of scoring sequences, increasing (positive momentum) versus decreasing (negative momentum), on psychological components (achievement goals, self-confidence, and competitive anxiety) in tennis matches. The results showed that negative events had greater psychological effect than positive events when looking

at the same variables. As expected, self-confidence was lower in the decreasing scenarios than increasing.

These studies mentioned earlier examine PM from the athlete's point of view. In a study by Moesch and Apitzach (2012) they used a different approach and interviewed coaches to ask them about their perception of PM of their players. They reported that they perceived positive PM in their athletes in association with happiness, joy and pride and negative momentum in association with stress and anxiety. Confidence was associated with continued positive performance and increased effort while lack of confidence was associated with negative performance and decreased effort (Redwood-Brown et al., 2017). These results agree with previous research where low self-confidence was associated with negative momentum (Gernigon et al., 2010). The coaches perceived that the opponents had a large impact on their players, influencing positive and negative PM. Similar results were found in a research by Redwood-Brown et al. (2017). They analysed the perception of PM of elite football players to be able to provide coaches with more useful tools for collecting PM data. The study contained ten elite male football players who participated in interviews and focus groups. Furthermore, 75 professional football players, with at least two-year experience at a professional academy, completed a questionnaire about their experience of PM. Positive attitude was reported to be associated with positive PM in this study which is supported by previous research (Jones & Harwood, 2008; Moesch & Apitzch, 2012). The most frequently reported variables associated with negative PM were being anxious as well as experiencing lack of ability. Experiencing negative PM seemed to lead to enhanced performance. This agrees with a study by Perreault et al. (1998) who suggested that experiencing negative PM would not always lead to decrease in performance. The variables most frequently reported in relation to positive and negative PM was scoring and conceding goals. This is supported by previous research where the importance of scoring goals in relation to experiencing PM has been highlighted (Vallerand et al., 1988; Stanimirovic & Hanrahan, 2004; Higham et al., 2005; Gernigon et al., 2010).

Behavioural momentum

The continuous debate and doubts whether psychological momentum exists in sports or not led some authors to turn their focus away from the psychological approach towards a behavioural approach within the field of sport psychology (Briki, 2017). Behavioural momentum (BM) has been defined as *"*... the relationship between response rate and resistance to behaviour change when certain 'disrupter' events occur" (Roane et al., 2004, p. 146).

Different analyses of BM have been reported in the literature. It is either analysed through serial dependency or non-stationarity (Briki, 2017). Serial dependency is when an event is dependent on a previous event while non-stationarity is when a performance of an athlete or a team in a game is better than would be expected by chance. Mixed evidence has been found in the literature regarding event outcomes, as to whether they are influenced by previous event outcome, within the same matches (Bar-Eli et al., 2006). There are also different levels of analysing BM. It can either be at the macroscopic level of outcomes (Iso-Ahola & Mobily, 1980; Jackson & Mosurski, 1997; Klaassen & Magnus, 2001; Hughes et al., 2006; O'Donoghue & Brown, 2009) or at the microscopic level of behaviours (Dumangane et al., 2009; Moesch et al., 2013). Previous studies have moreover suggested that the higher the reinforcement rate, the higher the response to adversity (e.g., Mace et al., 1992; Klaassen & Magnus, 2001; Hughes et al., 2006; Moesch et al., 2013). In a study by Mace et al. (1992) they examined if there was a relationship between local rate of reinforcement, the team's response to adversity, and the team's response to the opposing team taking a timeout. The analysis consisted of seven matches of 12 teams in the National Collegiate Athletic Association (NCAA) season in 1989. The variables used were for example type of shots, turnover, fouls, and outcome after possession. The results showed a positive relationship between the rate of reinforcement before adversity as well as between the rate of reinforcement and the team's response to the adversity. The team that was performing well before the adversity responded more positively to it than a team that was performing poorly before it. The results also showed that when a timeout was called by the opposing team it reduced the rate of reinforcement to the other team.

Wanzek et al. (2012) studied BM in volleyball and examined what influences momentum from different viewpoints. 40 matches of 12 teams and 113 female participants, competing in a high school league, were analysed. The variable used was serves and they looked to see if velocity and duration of successful serves could show BM. Disruption of momentum was also analysed by taking a timeout during a succession of serves. The results showed that the timeout did not reduce the velocity significantly for the serve straight after the timeout. No significant difference was found in duration of serves either. Furthermore, timeout did not affect the point outcome of matches or string of successful serves. The results indicate that timeouts are not a momentum disruptor in girl's high school volleyball.

Bar-Eli et al. (2006) suggest that the believe that momentum exists in sports is stronger than actual scientific evidence for it, which are limited. It is clear that streakiness does happen in sports and everyone who has played or watched sports have most likely experienced it.

However, the question is if the performance, when a team or an athlete are believed to have momentum, is any different than would be expected by chance. If it is, it is considered momentum. There has been mixed evidence in the literature as to whether momentum in sports does in fact exist or if it is possible to find statistical evidence to prove it (Bar-Eli et al., 2006). It has been argued that research on momentum lacks statistical power which might have affected results of studies that have not found evidence of momentum. Moreover, it has been suggested that sample sizes in previous momentum research have been too small to prove that it does exist (Weimer et al., 2023). However, with technology and increased statistical datasets and databases in sports, as well as novel statistical approaches, more convincing evidence of momentum in sports have appeared recently (Csapo & Raab, 2015a). Professional sports are a very competitive industry both in matches and outside of matches (Chen et al., 2021). It is important to be able to acquire advantage in professional sports and it can normally lead to individual or team success (Mellalieu & Hanton, 2010). Statistical analysis in sports can be used to learn about behaviour and performance of athletes and predict their actions under any given circumstances (Cervone et al., 2016). This can be used to enhance the performance of players (Chen et al., 2021).

There are several studies that have found evidence against momentum in sports (Albright, 1993; Stern & Morris, 1993; Frohlich, 1994; Vergin, 2000; Albert & Bennett, 2001; Clark 2003a; Koehler & Conley, 2003; Gula & Raab, 2004; Clark, 2005). An example of a study that did not find evidence of momentum was conducted by Adams (1992). They studied basketball field goals in 19 NBA games, analysing the performance of 83 players. They rejected their hypothesis regarding time dependent hot hand and no evidence of momentum was found. However, very limited variables were used in the analysis.

A summary of few studies that have provided evidence against momentum in sports are shown in table 1.

Table 1

Studies that provide evidence against the existence of momentum in sports.

Author(s)	Sport activity	Database	Results
Siwoff et al. (1988)	Baseball	1984-1987. All basketball games during these seasons.	Batting averages just as likely after cold streaks (negative momentum) as after hot streaks (positive momentum).
Gould (1989)	Baseball	Joe DiMaggio's 56-game hitting streak in 1941.	Streaks higher than expected by chance but is attributed to DiMaggio's overall success rate.
Larkey et al. (1989)	Basketball	1987-1988. 39 NBA games, 18 players (field goals).	No evidence of momentum. Half of players had positive momentum, the other half negative making the overall average zero.
Adams (1992)	Basketball	83 players in 19 NBA games (field goals).	Hit-hit time interval greater than hit-miss interval but not significant.
Albright (1993)	Baseball	1987-1990. 40 Major League Basketball players.	Streakiness of players same as would be expected by chance.
Vergin (2000)	Baseball	1996 season. 28 Major League Baseball teams, 162 games.	Wins and losses independent of the results of previous games and therefore no momentum. Streaks of winning and losing games no higher than expected by chance.
Clark (2003a)	Golf	1997 and 1998 PGA Tour and Senior PGA Tour (18-hole round scores data). 35 professional golfers.	Some streakiness found but was suggested to be related to the difficulty of the golf course rather than players being streaky.
Clark (2003b)	Golf	1997 and 1998. 25 Ladies Professional Golfers' Association (LPGA) (18-hole round scores data).	The results replicated the findings in Clark (2003a).
Koehler and Conley (2003)	Basketball	Four annual NBA Long Distance Shootout contests 1994-1997. 23 shooters.	No evidence of momentum or sequential dependencies.
Clark (2005)	Golf	1997 PGA Tour. 35 professional golfers (scores for each player analysed throughout the year).	Streakiness/momentum for only three players found (two had positive, one had negative). No player had momentum in individual tournaments.

Wanzek et al. (2012)	Volleyball	12 teams, 113 female players, 40 matches. Does velocity and duration of successful serves show momentum? Disruption of momentum also analysed.	Timeout did not reduce the velocity for the serve straight after timeout. No significant difference found in duration of serves. Timeout did not affect the point outcome.
Roberts and O'Donoghue (2014)	Netball	40 teams, 112 players, 20 matches in the British National Super League. Are current shots influenced by previous shots.	No relationship between previous shot and current shot.

Bar-Eli et al. (2006)

While there are some studies that have not been able to detect momentum in sports there are quite a few that have provided evidence supporting the existence of it (Tversky & Gilovich, 1989; Forthofer, 1991; Gilden & Wilson, 1995; Stern, 1995; Adams, 1995; Wardrop, 1999, Klaassen & Magnus, 2001; Raab, 2002; Smith, 2003; Frame et al., 2003; Dorsey-Palmateer & Smith, 2004; Arkes & Martinez, 2011). An analysis of momentum in pocket billiard was conducted by Adams (1995). The shot-by-shot scoring of 45 professional male players, during a nine-ball tournament, 1464 games in total, was analysed. The results indicated that the likelihood of winning a best of 21 match was greater if the first one or two games in the match were won. The likelihood of winning a game by running all balls was greater if the previous game was won by running all balls. These results suggest that success breeds success like has been suggested in the literature (Bar-Eli et al., 2006). Raab (2002) also found evidence of momentum when he analysed rows of sequences of successful spikes in 200 volleyball players. The analysis consisted of 226 German top national league games and 37.000 rows in total. The results showed that half of the players had a significant correlation between successful shots. Again, an example of a success that breeds success. Similar results were found in a study by Frame et al. (2003) when the final round of 1994-1998 Professional Bowlers Association (PBA) tournaments was analysed. Players won more than 50% of their next games if they won the previous game, despite playing against higher ranked bowlers. Another study on bowling was conducted by Dorsey-Palmateer and Smith (2004). The performance of 43 PBA players in the 2002-2003 season was analysed. The success of individual players was not independent of previous outcomes which means that a momentum was detected. If, however, a success is independent of previous success, it means

that there is no evidence of momentum. This was also the case when the performance of 64 horseshoe pitchers, 32 men and 32 women, was analysed during the World Championships in 2000 and 2001 (Smith, 2003). The probability of success was not independent of previous outcomes and momentum therefore detected.

A summary of few studies that have provided support for the existence of momentum in sports are shown in table 2.

Table 2

Studies that have provided support for the existence of momentum in sports.

Author(s)	Sport activity	Database	Results
Forthofer (1991)	Basketball	1989-1990. 123 NBA players (field goals).	17 players labelled streak shooters (had momentum).
Stern (1995)	Baseball	1987-1990. 40 Major League Baseball (MLB) players.	Evidence of momentum when players were analysed as a group but not individually.
Adams (1995)	Pocket billiards	45 players, 84 matches, 1464 games. Men's Professional Billiards Association (MPBA) nine-ball tournament.	The likelihood of winning a best-of-21 match significantly greater after having won the first (or first and second) games in the match. The likelihood of winning a game by running all balls greater after having won by running all balls in the previous game.
Klaassen and Magnus (2001)	Tennis	1992-1995 Wimbledon men's and women's singles (point-to-point data). 481 matches, 86,298 points.	Winning the previous point had a positive impact on winning the current point.
Raab (2002)	Volleyball	226 German first national volleyball league games. 200 players. 37,000 rows of sequences of successful spikes and misses.	Significant autocorrelation found between successive shots for half of the players (related to high base rates).
Smith (2003)	Horseshoe pitching	2000 and 2001 World Championships. 64 pitchers.	Success probabilities not completely independent of previous outcomes and momentum detected.

Frame et al. (2003)	Bowling	1994-1998. The Final Rounds of PBA tournaments.	Winners of each game won more than 50% of their next games (even when playing against higher-ranked bowlers).
Dorsey-Palmateer and Smith (2004)	Bowling	2002-2003. 43 Professional Bowlers Association (PBA) players.	Individual success probabilities neither independent of previous outcomes or constant across games for many bowlers.
Mortimer and Burt (2014)	Volleyball	Actions of both teams within 45 matches analysed. Based on the multidimensional model by Taylor and Demick (1994) Chain of actions defined as momentum.	Momentum found. Had positive effect on outcome in 86% of the matches analysed.

Bar-Eli et al. (2006)

Baseball has been a popular sport in the literature to analyse and try to detect momentum. Instead of examining a whole baseball team Gould (1989) focused on only one player, Joe DiMaggio, and analysed his 56 game hitting streak in 1941. The hits were well above what would be expected by chance which suggests momentum. However, this hitting streak has been attributed to DiMaggio‘s overall success rate which was very high compared to other players. Siwoff et al. (1988) analysed all baseball games from the 1984, 1985, 1986 and 1987 seasons. The batting averages for the players were just as likely to be higher following negative momentum streaks as following positive momentum streaks. Therefore, it was concluded that momentum did not affect the batting averages. Vergin (2000) studied the performance of 28 Major League baseball teams over the 1996 season, 162 games in total. Both wins and losses were independent of the match outcome in the previous games and streaks of either winning or losing were not higher than expected by chance. Similar results to the study by Siwoff et al. (1988) and no evidence of momentum found.

These studies mentioned earlier all analyse team sports and provide similar results regarding momentum. There are also previous studies on momentum in individual sports. Clark (2003a) examined momentum in golf where 18-hole round scores of 35 professional golfers were analysed individually on the Professional Golfers’ Association (PGA) Tour and Senior PGA tour in 1997 and 1998. Some evidence of streakiness were observed but it was

however assumed to be related to the difficulty of the golf course rather than the players being streaky.

When it comes to analysing data when studying momentum, the method is very important for the results. Interestingly, there have been studies where data has been analysed and no momentum detected and then another study has analysed the same data but used different methods and found evidence of momentum. A good example of this is a study by Albright (1993) where the performance of 40 Major League baseball players was analysed over 1987, 1988, 1989 and 1990 seasons. Some of the players had significant streakiness during some of the seasons but it was not higher than expected by chance. None of the players showed streakiness over all four seasons. Few years later Stern (1995) analysed the same data but instead of analysing the performance of each player individually they analysed the players as a group and found evidence of streakiness. This is a good example of how different methods can sometimes lead to different results. On a similar note, Miller and Sanjuro (2018) recently discovered a statistical flaw in the original research on momentum in basketball by Gilovich et al. (1985). A sequence bias was corrected, and the results did in fact show significant evidence of momentum for the shooters.

Timeout has been suggested to affect momentum in team sports. Players, coaches, and spectators believe that a timeout can stop momentum in basketball (Weimer et al., 2023). Timeouts can be used by coaches as a strategic intervention in team sports (Halldorsson, 2016). They are often taken by coaches when the opposing team has scored several sequential baskets while the other team has scored few to none (Gibbs et al., 2022; Weinbach, 2008; Roane et al., 2004). Timeouts are then taken to try to stop the momentum of the opposing team as it does interrupt the flow of the game. Halldorsson (2016) studied why coaches use timeouts in handball. This is not exactly momentum research but is related to the topic. The results suggested that coaches use timeouts when there is a negative flow in the game. This negative flow can also be defined as negative momentum of a team. Other reasons for the timeouts were for example resting players, changing game strategy, and slowing down the pace of the game. The results also indicate that the timeouts did in fact stop negative flow (negative momentum) in the game. Goldschmied et al. (2023) looked at how timeouts affect free throw performance in NCAA games close to their end. According to Saavedra et al. (2012) timeouts called by coaches near the end of a game are growing in use. The results showed that timeouts did affect free throw shooting in the last five minutes excluding the last minute. There was no effect in the last minute of the game. This is in accordance with previous research by Gómez et al. (2011) who found that timeouts in the last five minutes of a game are beneficial for resting

players, stop momentum and change the game strategy (Halldorsson, 2016). Similar results were found by Salitsky (1995) in volleyball. They observed that a team with positive momentum before a timeout decreased the number of points gained after a timeout. Weimer et al. (2023) analysed how official timeouts affects momentum in basketball. Official timeouts occur at a specific time in a basketball game and are not related to the score of the game or momentum of either team. Unlike timeouts called by coaches, that are used strategically to stop momentum, official timeouts only coincidentally interrupt momentum (Weimer et al., 2023). The results of the study showed that official timeouts caused the number of points to decline by 11.2% for the team that had positive momentum before the timeout. It would certainly be interesting to include time outs in future momentum research in basketball in Iceland.

There are number of factors that can influence performance of athletes. Previous research has for example suggested that moving away from a win has negative effects on both psychological and behavioural states of athletes. The reverse has been suggested for moving towards a win and that it has positive affects on both psychological and behavioural states of athletes (Briki et al., 2012; Gernigon et al., 2010; Stanimirovic & Hanrahan, 2004). Research has also shown that winning games can potentially increase testosterone levels of the athletes while losing games can potentially decrease these levels (Mazur, 1985; Archer, 2006). Increased testosterone levels can lead to enhanced human performance which is beneficial for athletes (Booth et al., 1989; Salvador et al., 2003; Edwards, et al., 2006). This increase after winning a game can boost the self-confidence of athletes as well as aggression and risk taking (Morgulev, 2023) which can lead to improvements in performance (Geniole & Carré, 2018). It has also been suggested that winning can increase dopamine levels in the brain, which are related to positivity and motivational enhancements (Morgulev, 2023). This can lead to athletes being more goal oriented and relaxed when competing which can lead to them experiencing that they are in control (Norbury et al., 2013; Robertson, 2018).

Momentum in basketball

Gilovich et al. (1985) were the first to investigate momentum in basketball and if it was possible to prove its existence with statistical data. They used three types of shots in their analysis: field goal data of nine professional basketball players, free throw data of other nine professional basketball players, and controlled shooting experiment of 26 varsity players from a university. They used a runs test and serial correlations in their analysis. The results showed that field goals and free throws were significantly independent of the outcome of the previous shots and therefore there was no momentum detected. No relationship was found between

successive shots (Bar-Eli et al., 2006). It can be argued that this research only looked at shots and did not include other variables that might affect the shot outcomes. Basketball is a fast game where defensive pressure plays a big part and can influence shots for example. Therefore, it is important to include defensive variables in a study like this.

A few years later Twersky and Gilovich (1989) conducted a research on momentum in basketball and also failed to find evidence of it. In the first stage of the research, they used a questionnaire for fans to see what they experienced to be momentum, or the hot hand, in players. A total of 91% of the fans believed that a player had a better chance of making a successful basket after making two or more successful baskets prior, rather than if the previous two or three shots were unsuccessful. When it came to free throw shots, the fans believed that a player was more likely to make the second free throw shot if the first one was a success, rather than if the previous free throw shot was unsuccessful. A total of 84% of fans thought that it was important to pass the ball to a player who had a hot hand. In the second stage of the research, they used real data and free throw data from the NBA games, and controlled shooting experiment with varsity players, both males and females. They used statistical analysis to test the existence of the hot hand using a runs test and correlations. No evidence was found that momentum existed and therefore they concluded that a given shot of a player was independent of previous shots of that player (Bar-Eli et al., 2006). This study is a great example of how spectators believe that momentum exists in sports, but the statistical analysis does not always support that believe. Following this research many follow up studies were conducted in various sports such as baseball (Albright, 1993; Frohlich, 1994; Stern, 1995; Vergin, 2000; Albert & Bennett, 2001), volleyball (Raab, 2002; Wanzek et al., 2012), tennis (Klaassen & Magnus, 2001; Gernigon et al., 2010), golf (Gilden & Wilson, 1995b; Clark, 2005), darts (Gilden & Wilson, 1995b), pocket billiards (Adams, 1995), bowling (Frame et al., 2003; Dorsey-Palmateer & Smith, 2004) and horseshoe pitching (Smith, 2003). Research on momentum has not only been an interest in sports but other academic fields as well such as religion, law, economics, and cognitive science (Bar-Eli et al., 2006). According to Morgulev et al. (2019) and Morgulev et al. (2020) momentum is one of the most commonly used term when it comes to performance, whether it is in sports, politics, business, etc.

The momentum metaphor is a well-known phenomenon in basketball and is frequently described as the hot hand or streakiness as mentioned earlier (Bar-Eli et al., 2006). When a player is on a hot streak and keeps making successful baskets it is common for people to believe that this player will be successful in the next shot attempt as well. Simultaneously, when a player is on a cold streak and keeps missing his or her shots it is believed that the next shot

attempt will be unsuccessful as well. This streakiness is likely associated with the athlete's self-confidence. When there is an increase in confidence it leads to the player being more relaxed and focused leading to shots being performed accurately (Hales, 1999). However, when player's self-confidence increases he or she tends to take shots from more difficult locations and angles which can lead to a failed shot attempt and therefore end of streakiness (Koehler & Conley, 2003). Another factor that might influence a player with positive momentum are the defending players who tend to increase the defensive pressure on that player they believe is on a hot streak (Csapo & Raab, 2015a). Sometimes players on a team tend to pass the ball to a player they believe has a hot hand because they believe that the player has a higher probability than other players of making the next basket (Burns, 2004). That player believed to have a hot hand might therefore get more shot opportunities than other players and more opportunities to score because of the ball being passed more often to him or her. Coaches also tend to keep players they believe have positive momentum longer in the play as they believe they are likely to make successful baskets (Vergin, 2000).

Keohler and Conley (2003) analysed four NBA long distance basketball shootout contests from 1994 to 1997. The aim of the study was to detect momentum in natural basketball setting as the shootout contest includes large audience, professional players, professional court, high stakes ($20,000 price for winning) and television audience. They conducted a runs test to look for streakiness for each player. If a player had a hot hand or positive momentum, he should have had fewer runs than was expected by chance. The shooting performance was analysed based on previous shot and if it was successful or unsuccessful. The results showed no evidence of momentum or sequential dependencies. It can be argued that a shootout contest is not the same as a game situation, so it is unclear how relevant these results are compared to results from a game. Roberts and O'Donoghue (2014) got similar results when analysing BM in netball. They examined if current shots were influenced by previous shots. They analysed shooting performance of 40 teams and 112 players, in 20 matches in the British National Super League. The variables used were shot outcome, number of marking defenders, shot location and if the foot of the shooter moved during the shot or not. No evidence was found that current shot outcome was significantly influenced by the previous shot outcome. There are few possible explanations for this outcome according to the authors. For example, the experiment is not controlled so there are some factors outside of the researcher's control. Another explanation might be that some shots happen during open play where there are defenders and other shots are from penalties were there are no defenders. Roberts and O'Donoghue (2014) also suggested that the athletes in the study are at a high level, so they have a high percentage

of scoring shots. Therefore, the players might think of missed shots like something that happens only occasionally and have developed psychological skills to cope with failed shots. Very different results to Roberts and O'Donoghue (2014) were found when momentum in elite handball was examined by Mortimer and Burt (2014). They analysed the actions of both teams within 45 matches and based their methods on the multidimensional momentum model by Taylor and Demick (1994). A chain of actions of a team was defined as momentum and the chain had to consist of three actions in the correct order: goal scored – turnover – shot. Their findings were however in accordance with another study by Moesch and Apitzch (2012) and suggested that momentum does exist in elite handball and had positive effect on outcome in 86% of the matches analysed. Another study that found evidence of momentum was conducted by Arkes (2010) who analysed free throw basketball data from the 2005-2006 NBA season. They used multivariate framework with individual fixed effects. The results showed that there was a higher probability of making the second free throw shot if the first shot was successful. Arkes and Martinez (2011) used data from three NBA seasons 2007-2009 to analyse if previous three to five successful games increased the probability of winning the next game. The results showed evidence of momentum where successful performance in the previous three to five games was associated with winning the next game. The home teams had a stronger estimated effect than away teams. Vergin (2000) tried to identify BM in professional basketball and baseball by analysing winning and losing streaks over a season. The results suggested that momentum was not as an important factor influencing performance as sports participants and spectators want to claim. Previous studies who have failed to detect BM in sports have been criticized for their methods and variables used in the analysis (Koehler & Conley, 2003). Many of these studies have for example excluded the effect of defensive pressure to simplify the research (Csapo & Raab, 2015a). Defensive pressure plays a big part in most team sports so it is likely an important variable when it comes to analysis of momentum in the basketball. For example, when the shot distance increases the defensive pressure decreases (Csapo et al., 2014).

It has been argued that it is not possible to detect momentum in basketball due to the nature of the game and defensive interference of the opposing team (Csapo & Raab, 2015a). When a player has positive momentum, the opposing team tends to adjust their defending strategies to stop the streakiness (Gilovich et al., 1985). They might for example guard that player more carefully forcing him or her to make more difficult shots which might result in a missed shot that affects the momentum (Csapo et al., 2014). Therefore, it essential to include defensive variables in BM research on basketball. Vencúrik et al. (2022) analysed shooting

efficiency in basketball but not related to momentum. They found that defensive pressure and the distance from the basket when a shot was taken, did significantly affect shooting efficiency. With higher defensive pressure, the shooting efficiency was lower. The only study found using defensive pressure when analysing BM in basketball is by Csapo and Raab (2014). They used number of different performance variables in addition to defensive pressure. Data from 666 NBA games from two seasons was used in the analysis including 94.056 shot attempts, to analyse how the shooting percentage of the players change in relation to the attributes of each performance variable. The variables used were shot type, dribbles, remaining time on shot clock, shot location, last action before acquiring the ball, number of defenders and defensive intensity. Their results suggest that defensive intensity has a greater impact on shot difficulty rather than number of defenders. Secondly, they analysed how the performance variables and shooting accuracy change as part of a streak length. The results show that defensive pressure and shot difficulty increases during hot streaks and decreases during cold streaks. This suggests that defending players behave according to the hot hand belief and force players who they believe are on a streak to take more difficult shots. The shooting percentages of these players believed to be on a streak did however not increase, and therefore no evidence of the hot hand was detected when looking at defensive pressure. Csapo et al. (2015b) included 18 professional basketball coaches and 20 players in their study on BM in basketball. They used video sequences from the National Basketball Association (NBA) games. The coaches were asked to come up with a defensive strategy for players that displayed streaky performance after each run of streakiness. The players were asked to decide to either pass the ball or shoot in a streaky situation. The results show that the coaches tended to increase the defensive pressure on streaky players significantly more often and therefore making use of the believe of the hot hand effect. This is in accordance with Perreault et al. (1998) who suggested that coaches regularly set up their teams and plan the game strategies based on players who seem to have momentum. The players however chose to shoot more often than to pass the ball when they had positive momentum. Simultaneously, the players chose to pass the ball rather than shoot in situations where defensive pressure was increased. These results are in accordance with Gernigon et al. (2010) who suggest that players with positive momentum have more self-confidence while players with negative momentum have less self-confidence.

Csapo et al. (2014) studied BM in basketball and based their research on previous studies by Aharoni and Sarig (2012) and Attali (2013). They analysed data from 1216 NBA games and the study consisted of two phases. In phase one they looked to see if shot distance, shot type, and shot angle could be used as a proxy for shot difficulty in research. In phase two

they analysed positive and negative momentum (hot and cold streaks) of the top ten scorers in the NBA during the 2009 and 2010 season and if the streaks influenced the three shot variables. The results are similar to previous research and show that the more successful shots players make, the following shots tend to be more difficult (Koehlet & Conley, 2003). Simultaneously, the more missed shots players make the following shots tend to be less difficult. While most studies focus on how positive momentum affects performance this study is one of few that also looks at the influence negative momentum has on performance.

Only two studies were found that have analysed momentum in women's basketball. Roane et al. (2004) conducted twofold research on women's college basketball. Firstly, they examined the relative rate of reinforcement of their sample. The results were then compared to the results of the investigation by Mace et al. (1992) to see the difference between samples. Secondly, they examined the relationship between the local reinforcement rates before and after adversities, which were defined as turnovers and fouls for example, in relation to the opponents calling timeout. The results indicated that the local reinforcement of the current sample was relatively lower than the sample of Mace et al. (1992), which included male players. When the opposing team called timeout the local rate of reinforcement of the target team decreased. The results showed that momentum does exist at a team level and that timeouts can be used to reduce the momentum of the opposing team. These findings are similar to the results of Mace et al. (1992). The other study found on women's basketball was conducted by Wardrop (1999) who used a controlled shooting experiment for one female varsity basketball player. She would shoot 100 shots behind the three point arch for 20 days during her off season. They hypothesized that the shots would follow a Bernoulli trial but the results showed significant statistical evidence against it and therefore displaying evidence of momentum.

When it comes to research on momentum in basketball there are weak evidence of it in game settings but strong evidence of it in controlled settings (Arkes, 2010). Previous research has mainly used three types of shots in their analysis: field goals, free throws, and shots from a controlled experiment (e.g., Gilovich et al., 1985; Larkey, 1989; Twersky & Gilovich, 1989; Adams, 1992; Wardrop, 1995; Arkes, 2010; Goldschmied et al., 2023). When testing for momentum in basketball it is very difficult using field goals due to the nature of the sport, but not impossible. Many factors can influence the outcome of shots which are important to include in the analysis of field goals to get more accurate results. The defending players are a crucial factor that should be taking into consideration when analysing field goals. A player can have a weak defending player against him or her that allows them to attack towards the basket easily and get open shots. The chance for this player to make a basket is quite high. Another example

is if a player has a strong defending player against him or her that forces them to take shots from a difficult location or angle or not even be able to take a shot and having to pass the ball to another player. The chance for this player to make a basket is lower than if the defending player was weak. Another factor that can influence shot outcome is when players just naturally mix up where they take their shots on the court which can change between possessions. It could be beneficial to include the location of shots when analysing field goals when testing for momentum. Most of previous research on momentum in basketball have not included variables that can affect shot outcomes, like the ones mentioned earlier, which might contribute to the results of not finding evidence of it.

Using free throw data when studying momentum is not as difficult as using field goal data. Each free throw shot is the same, from the same location, with no defenders. There are very few factors that can influence free throw shots but are for example the pressure of taking a free throw shot and fatigue of the player. Controlled shooting experiments might therefore be considered the most thorough test when studying momentum in basketball because there are very few factors influencing the shot outcome. Miller and Sanjurjo (2021) used data from the NBA Three-Point Contest over 34 years (1986-2020) in their study. They collected their data using television broadcast of the matches. They found significant evidence of positive momentum both for individual players as well as across individuals. No evidence was found of negative momentum. These results do not mean that negative momentum does not exist. Other studies have found evidence of it using controlled shooting experiments, significantly higher for non-professional players compared to professional players (Miller & Sanjurjo, 2014). From these results it can be suggested that professional players are more skilled to maintain positive momentum and end negative momentum (Miller & Sanjurjo, 2021). Although controlled shooting experiments could be ideal for analysing momentum, controlled shooting in a gym is very different from shooting in an actual basketball game so it is unclear how relevant the results are compared to a game situation. Lantis and Nesson (2021) used free throw shooting of NBA players and the NBA Three-Point Contest in their study. Small momentum effect was found in the controlled settings, but they argue that it does not exist within in-game situations. Based on these results it might be beneficial to include both controlled shots such as free throws as well as field goals when analysing momentum in basketball. Wardrop (1995) analysed free throw data similar to Gilovich et al. (1985) when studying momentum in basketball. They suggested that analysing players as a group could give false results of momentum. For example if there is a player who is very good at free throws it is likely he or she will make the first shot. Vice versa if there is a player who is not very good

at free throws it is more likely he or she will miss the first shot. Hence, it is more likely that successful shots will be followed by successful shots and missed shots will be followed by missed shots. It might therefore be more accurate to analyse each player when studying momentum.

Arkes (2010) suggests that future research should include various variables when analysing the existence of momentum in basketball for a more in-depth analysis.

Manuscript

Abstract

Objectives: To determine if: (I) shot outcome is associated with the outcome of the previous shot, (II) if shot outcome is affected by performance variables of shots, and (III) if performance variables of shots are influenced by the previous shot outcome.
Methods: Shooting performance in 10 matches, 20 team performances, in the women's basketball top-division in Iceland analysed (n=128). Seven performance variables recorded for each shot. Chi square tests of independence determined if there was an influence of previous shot outcome on current shot outcome, and if different locations and comparing them in terms of percentage scored. Wilcoxon tests to compare how often each shot location was chosen after the previous shot was scored or missed. Wilcoxon and Friedmans tests used when analysing shot outcome with shot location. Wilcoxon and Friedman test to analyse shot outcome with the performance variables, and Wilcoxon tests to see the effect previous shots had on performance variables.
Results: Three of the 20 team performances showed significant association between shot outcome and previous shot outcome ($p<0,05$). Shot outcome did not significantly influence subsequent shot location ($p>0,05$). Significant association between performance variables and current shot outcome was detected ($p<0,05$) but no significant association found between the previous shot outcome and the performance variables for the current shot ($p>0,05$). The results did not favour any of the theoretical models of momentum over others.
Discussion: The lack of momentum in most performances may be explained by the lower shooting accuracy in the Icelandic top-division (fewer than 50% of 2 point attempts scored). Addressing shot location when studying momentum cannot be justified by the current findings. Performance variables significantly affect shot outcome, but previous shot outcome does not affect performance variables.

Keywords: Basketball, momentum, hot hand, streakiness, shot outcome

Introduction

In sports it is a common belief that "success breeds success and failure breeds failure" (Bar-Eli et al., 2006, p. 526). This is what research has termed as *momentum*, also known as *the hot hand* or *streakiness*. It is the belief that a performance of an athlete or a team is temporarily better than would be expected based on previous performances (Gilovich et al., 1985; Koehler & Conley, 2003). Momentum can both be used about a team winning or losing consecutive games or about a performance of an individual player or team within a game (Arkes & Martinez, 2011). There is a debate in the literature and to this day the question to whether momentum does exist in sports or not remains unresolved (Bar-Eli et al., 2006).

Momentum in sports has been widely investigated either through a psychological approach (e.g., Vellerand et al., 1988; Taylor & Demick, 1994; Cornelius et al., 1997; Gernigon, 2010; Moesch & Apitzach, 2012; Iso-Ahola & Dotson, 2014) or a behavioural approach (e.g., Mace et al., 1992; Vergin, 2000; Koehler & Conley, 2003; Csapo & Raab, 2015a; Wanzek et al., 2012; Roberts & O'Donoghue, 2014; Redwood-Brown et al. 2017).

It has been argued that it is not possible to detect momentum in basketball due to the nature of the sport. However, most of previous studies that have examined momentum in the sport have excluded the effect of defensive pressure to simplify the research (Csapo & Raab, 2015a). In this study we will include opposition disposition to see if it affects shot outcomes, as defensive pressure is an important factor in basketball. Similar research has been done in netball (Roberts & O'Donoghue, 2014) and handball (Mortimer & Burt, 2014), using similar variables, and one in basketball to our knowledge (Csapo & Raab, 2014).

The aim of this study was to investigate the concept of momentum, using a behavioural approach, in Icelandic women's top-league basketball. There have been limited studies on momentum in women's basketball to this day in the world, and only two studies on the topic found (Wardrop 1999; Roane et al., 2004). No research has been done on momentum in any sport in Iceland to this day.

Methods

Matches

The shooting performance in 10 matches in the Icelandic women's basketball top-league was analysed. The participants included the 128 players within the 10 teams of the league. The number of matches analysed was originally based on netball research by Roberts and O'Donoghue (2014) who used similar variables and methods as the current study. They analysed shooting performance of 40 teams and 112 players, in 20 matches. However, the time that it takes to collect shooting data from one basketball match takes approximately 2 to 2,5 hours. Based on the ECTS and estimated hours to finish this project we had to analyse half as many matches as they did in the netball study. The analysis included 20 team performances and 20 player performances. The games were selected based on television broadcast and included the following teams playing in the top-league: Breiðablik, Fjölnir, Grindavík, Haukar, Keflavík, Njarðvík, Snæfell, Stjarnan, Valur and Þór Akureyri.

Type of study and data collection

The current study is an analytical cross-sectional study. The data was obtained by watching each of the 10 matches. Every shot was analysed and the variables in play registered in Microsoft Excel.

Variables

There were six independent variables that were recorded for each shot:

1) The player who took the shot
2) Opposition disposition
3) Shot location
4) Shot type
5) Whether the shot occurred during a fast break or other type of possession
6) Whether a dribble was made or not

The dependent variables, shot scored and shot missed, were also recorded

Players and positions

Each player was registered with their playing number and their team in the Excel spreadsheet. Registering the team next to the playing number made it easy to distinguish between players with the same number on different teams.

Opposition disposition

Opposition disposition was split into three categories. Category 1 was when the attacking player was outnumbered by defending players. Attacking player being the one who took the shot. The defending players are defined as the opposing players that affected the shot in any way: placed between the attacking player and the basket, reaching for the ball, touching the attacking player, etc. Category 2 was when attacking and defending players were equally as many. This was when there was one defending player affecting the shot of the attacking player. Category 3 was when there were no defending players affecting the attacking player or anywhere near them.

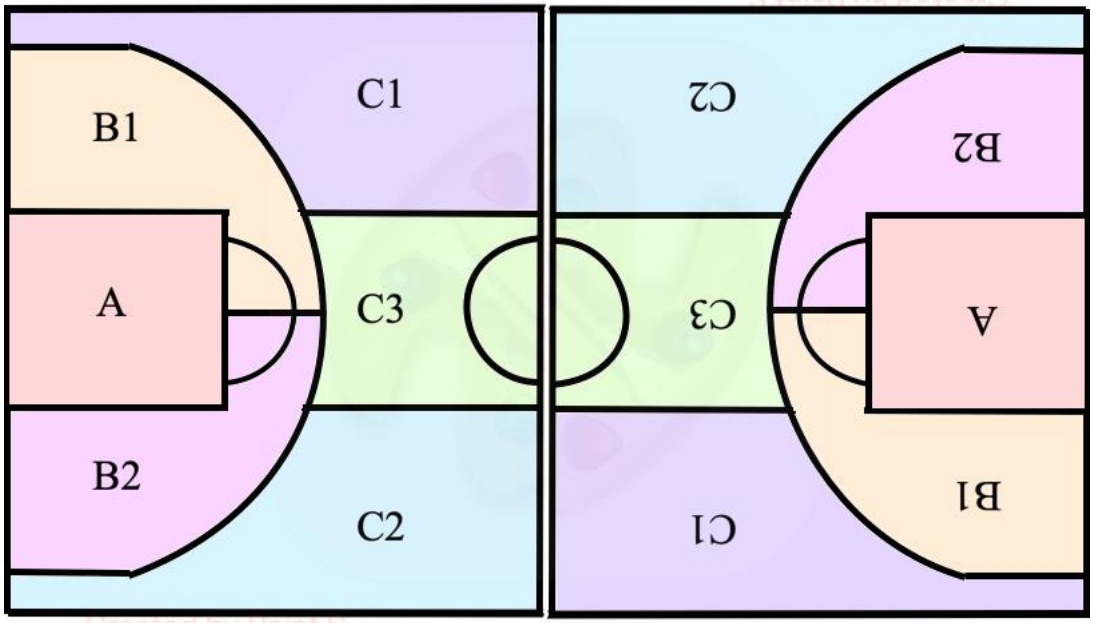
Shot location

Very few studies on momentum in basketball have analysed shot location based on specific areas of the court. Mace et al. (1992) used 3 pointers, 2 pointers and free throw shots as variables but did not specify the location of the shots. Csapo et al. (2014) did a study on basketball and divided the court into six equally large sections. The basket was used as the centre and each section had a 30° interior angle. This does not consider the distance from the shot location to the basket and therefore will not be used in this study. The basketball court in the current study was divided into six areas based roughly on research by Szwarc and Lekner (2012) and Mateus et al. (2020). These studies were not focusing on momentum but were however studying different shot locations in basketball.

When analysing the shot location, we looked at different shot locations and compared them in terms of percentage of shots that were scored.

Figure 1

A diagram of the court divided into six locations



Shot type

Shot type was divided into categories based on the points received for the shot. The first category was free throw shots, where each shot gives one point. The second category was 2 point shots and the third category was 3 point shots.

Possession type

Possession was divided into two categories. The first category is when the shot occurred during a fast break and the second category is when a shot occurred after any other type of possession.

Dribbles

Dribbles were divided into two categories. The first category was when a player dribbled before taking a shot. The second category was when a player did not dribble before taking a shot.

Data analysis

All data was analysed using Microsoft Excel and IBM SPSS Statistics software. A series of statistical tests were conducted on the shooting performance of each player within the 10 matches. Free throw shots, 2 point shots and 3 point shots were analysed separately for each test:

- Chi square test of independence was used to analyse if the current shot outcome was independent of the previous shot outcome.
- Chi square test of independence was conducted to look at different locations and comparing them in terms of percentage of shots that were scored.
- Wilcoxon tests of independence were used to compare how often each shot location was chosen for the current shot after previous shots were scored or missed.
- Friedmans test, for variables with three categories, and Wilcoxon tests, for variables with two categories, were used to analyse the affect the performance variables had on the current shot outcome.
- Wilcoxon tests of independence were used to analyse if the previous shot outcome had any influence on the performance variables for the current shot outcome. The analysis was to compare the same variable for the previous shot and the current shot.

Results

A comparison of scoring the current shot after scoring the previous shot, and scoring the current shot after the previous shot was missed, for all the teams, is shown in table 3. A chi square test of independence was used for the analysis. No statistical significance was found when all the teams were analysed together with the three types of shots being analysed separately. When the matches were analysed separately, a p value less than 0,05 was found in four of the matches and is shown in table 3.

Table 3

Chi square test of shot outcomes versus previous shot outcomes

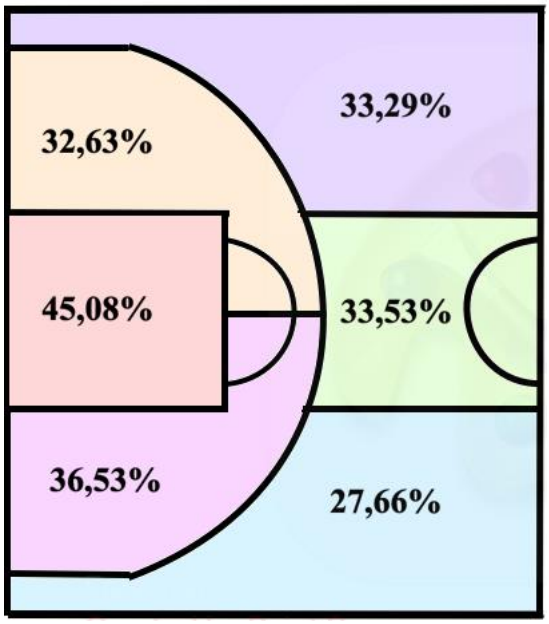
Team	Type of shots	%scored after a miss	%scored after scoring	p value
All	1	70,9	72,4	0,800
All	2	40,9	44,8	0,246
All	3	28,9	32,7	0,367
Stjarnan vs Haukar	2	5/27 = 18,5%	8/13 = 61,5%	0,007
Valur vs Keflavík	2	10/33 = 30,3%	0/10 = 0%	0,047
Breiðablik vs Njarðvík	2	5/24 = 20,8%	8/13 = 61,5%	0,013
Valur vs Keflavík	3	2/18 = 11,1%	3/5 = 60%	0,019

Note: The results from a chi square test and the matches where significant difference was found and p value was below 0,05.

Figure 2 shows the percentage of shots from each location that were successful. A chi square test of independence was used in the analysis. The highest shot success was from location A (45,08%) just under the basket. The other locations have similar success rate, ranging from 32.63% to 36.53%, except for location C2 (27,66%) which has relatively lower success rate than the other locations. The three locations for 2 point shots and three locations for 3 point shots were analysed separately to see if there was a significant location effect. No significant difference was found between the locations for 2 point shots (p=0,155) or for 3 point shots (p=0,496).

Figure 2

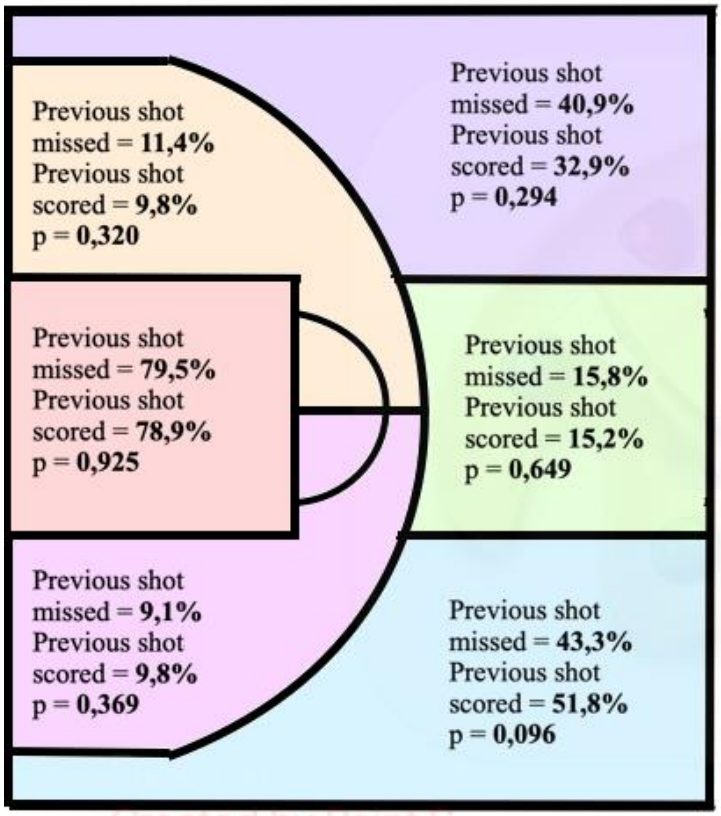
The percentage of successful shots from a specific location



The results from Wilcoxon tests analysing shots from different locations is shown in figure 3. Free throw shots were excluded from the analysis because they are always taken from the same location (A) and previous shot outcome did not affect where the next free throw shot will be taken. The results shown in the diagram (figure 3) show how likely a player is to choose a specific location after missing or scoring the previous shot. Unlike the previous analysis the percentage of shots taken from the three locations adds up to 100 percent. This is the case when the previous shot was missed and when the previous shot was scored. The 2 point shots and 3 point shots were analysed separately. The Wilcoxon tests showed no significant difference in the percentage of shots taken from any location between when the previous shot was scored and when the previous shot was missed.

Figure 3

The likelihood in percentages of players choosing a location based on the previous shot



Note. The percentage of shots taken from each location depending on the outcome of the previous shot and the p value after comparing previous scored shots and missed shots from the same location.

The affect the variables had on the current shot outcome was analysed using Friedman test for opposition and Wilcoxon tests for dribbles and fast breaks (table 4). The opposition had three different categories (1, 2 and 3) while the dribbles and fast breaks only had two each (dribble and no dribble, fast break and other type of possession). The results show that defensive situation of opponents did affect outcome significantly for both 2 point shots (p=0,011) and 3 point shots (p=0,028). Teams were significantly more likely to score after they dribble before taking a shot (p=0,004). Fast breaks were only analysed for 2 point shots as it is very unlikely that players try to do a 3 point shot from a fast break rather than going closer to the basket and doing a 2 point shot. Teams were significantly more likely to score a 2 point basket during a fast break than during other type of possession (p=0,030).

Table 4

The mean and standard deviation for the effect the variables had on the current shot outcome

Variable	Successful 2 point shots (%)	Successful 3 point shots (%)
Dribble	38,10±12,20	39,01±30,63
No dribble	51,4±15,29	27,59±11,17
Fast break	59,73±33,02	$$$
Other type of possession	43,23±5,61	$$$
Opposition (1)	58,30±32,65	35,65±23,15
Opposition (2)	41,31±9,79	29,04±10,24
Opposition (3)	34,81±17,58	14,29±37,80

Note: $$$ means that not enough shots were taken to analyse.

The affect the previous shots have on the variables for current shots was analysed using a Wilcoxon tests and is shown in table 5. The outcome of the previous shot did not affect the defensive situation for the next shot significantly, neither 2 point shots (1: p=0,765, 2: p=0,983, 3: p=0,629) or 3 point shots (1: p=0,421, 2: p=0,968). There were very few 3 point shots when the opposition was 3 (defending players outnumbering the player taking the shot) and therefore it was not included in the analysis. Previous shot outcome did not change how often teams dribbled before the next shot, neither for 2 point shots (p=0,232) or 3 point shots (p=0,881). Similar results were found for fast breaks. Scoring did not significantly increase or decrease the chance of team using a fast break on their next possession (p=0,391). Like the previous analysis, only 2 point shots were analysed for fast breaks.

Table 5

The mean and standard deviation for the affect the previous shot outcome has on the variables in the next shot

Variable	When you score the previous shot	When you miss the previous shot	P value
2 point attempts			
Dribble	67,48±13,69	62,53±16,73	0,204
Fast break	9,47±6,56	8,05±9,09	0,376
Opposition (1)	10,27±6,11	11,08±9,92	0,765
Opposition (2)	63,72±11,22	63,40±12,29	0,983
Opposition (3)	25,21±11,97	26,33±12,45	0,629
3 point attempts			
Dribble	19,50±20,40	16,86±11,02	0,500
Fast break	$$$	$$$	$$$
Opposition (1)	16,14±11,69	18,47±11,01	0,421
Opposition (2)	80,54±13,81	80,84±11,22	0,968
Opposition (3)	3,33±7,33	0,69±1,71	$$$

Note: $$$ means that not enough shots were taken to analyse.

Discussion

The objectives of the current study were: (I) to determine if shot outcome is affected by the outcome of the previous shot, (II) if shot outcome is affected by with performance variables of shots, and (III) if performance variables of shots are influenced by the previous shot outcome.

The influence of previous shot outcome on current shot outcome

The results from analysing the effect the previous shot outcome has on the current shot outcome showed that there was a slightly higher percentage of shots scored after the previous shot was scored, when compared to shots scored when the previous shot was missed, for all types of shots (table 3). Although the percentage of scoring a shot after scoring

the previous shot was higher than after missing the previous shot there was no statistical significance found with the p values for all types of shots being higher than 0,05. This agrees with previous studies. In the first research on momentum in basketball by Gilovich et al. (1985), they found that current shot outcome was significantly independent of the previous shot outcome for both free throws and field goals, and no momentum was found. Koehler and Conley (2003) produced similar results and no evidence of momentum or sequential dependencies. It can be argued that these two studies excluded defensive pressure in their research which might have an influence on the results. Lantis and Nesson (2021) conducted similar research but included more performance variables in their study including a variable for opposition but different from the current study. They analysed how far away from the shooting player the defending player was, when the shot was taken. Their results showed that a player was not more likely to score a basket after scoring the previous basket. Roberts and O'Donoghue (2014) used similar variables as the current study in their research on netball shooting and found no evidence that the current shot outcome was significantly influenced by the previous shot outcome.

Although no momentum was detected when analysing all the teams together, four team performances showed momentum (table 3). A significant difference was found for Stjarnan when playing against Haukar (p = 0,007) and for Breiðablik against Njarðvík (p=0,013), with 61,5% chance of scoring a 2 point shot after scoring the previous 2 point shot for both Stjarnan and Breiðablik. A p value of 0,047 was found for Valur in a match against Keflavík for 2 point shots. However, the percentage of scoring a 2 point shot after scoring the previous 2 point shot was 0% which means that Valur did not score two 2 point shots in a row in the match and therefore the opposite of momentum was found. The p value for 3 point shots for Valur in the same match was 0,019 which suggests momentum with 60% chance of scoring a 3 point shot after scoring the previous 3 point shot. However, the team only made five 3 point shots in total in the match which makes it difficult to conclude that it really is momentum. These results suggest that it might be worth analysing individual team performance rather than using an out and out reductive approach when studying momentum in sports.

When analysing the percentage of successful shots taken from each location the results showed that the highest percentage of successful shots were taken from location A, just under the basket (figure 2). This is to be expected as location A is the closest a player can get to the basket when taking a shot. The other locations had similar percentage of successful shots. There are multiple factors affecting where a player takes a shot, defensive pressure,

time on the clock and the defensive pressure for example. A player cannot always choose the location they take the shot from, although sometimes they can. Previous study by Roberts and O'Donoghue (2014) suggests that players tend to take shots from further away after scoring the previous shot.

The influence the performance variables have on the current shot outcome

The analysis on the effect the other performance variables have on the current shot outcome showed significant difference for all variables (table 4).

Defensive pressure plays an important factor in basketball and is therefore an important variable to include when analysing momentum. Other studies have analysed shooting efficiency in basketball, not related to momentum, using performance variables similar to the ones used in the current study. Vencúrik et al. (2022) found that defensive pressure and the distance from the basket when a shot was taken, did significantly affect shooting efficiency. With higher defensive pressure, the shooting efficiency was lower. This is in accordance with the findings in the current study where the defensive situation was found to affect current shot outcome significantly for both 2 (p=0,011) and 3 point shots (p=0,028). The number of 3 point shots taken were very few compared to the other type of shots which might have affected the results for the 3 point shots. These results are to be expected, that the number of defending players affecting a shot does influence the outcome of the shot. A player is more likely to score a basket if no defending players are affecting the shot and less likely to score a basket when the defending players are outnumbering the player taking the shot (table 4).

Teams are significantly more likely to score when they dribble before taking the shot (p=0,004). This disagrees with a previous study by Csapo and Raab (2014) who found that shots taken without dribbling before had a higher chance of being successful than shots after a dribble.

Teams are significantly more likely to score during a fast break than during other type of possession (p=0,030). The possible reason as to why fast breaks lead to score more percentage of time than other type of possession could be due to the number of defending players affecting the shot. When a fast break occurs, there are usually limited number of defending players affecting the shot, and like mentioned before a player is more likely to score a basket if no defending players are affecting the shot.

The influence previous shot outcome has on performance variables of the current shot

When analysing the likelihood of a player choosing a location for the current shot after scoring or missing the previous shot, the results showed no significant difference for any location (figure 3). However, there was a considerable difference in location chosen for shots, both after missing and scoring the previous shot. The most chosen location was location A with the highest percentage of shots after the previous shot was missed (79,5%) and after the previous shot was scored (78.9%). This is to be expected as mentioned before as it is the closest a players can get to the basket to take a shot.

When looking at how previous shot outcome affects the other performance variables for the current shot outcome the results showed no significant difference for any of the variables (table 5). These results disagree with previous study by Mortimer and Burt (2014) on handball where they used a simplified version of the multidimensional model by Taylor and Demick (1994) as a conceptual model. They found that after a successful shot the chance of forcing turnover before the opposing team could take a shot was higher for eventual match winners. After forcing the turnover, the chance of taking a shot was higher for the eventual match winners. The team completing the momentum chain successfully had positive effect on outcome in 86% of the matches analysed.

The outcome of the previous shot did not change defensive situation for the next shot significantly. This is something that is more in the control of the defending team rather than the team with the ball. Previous shot outcome did not change how often teams dribbled before the next shot and it did not significantly increase or decrease the chance of a team using a fast break on their next possession. This might be because the opportunity for a fast break depends on multiple dynamic factors to do with how and when the team got the ball and how the defending team lost the ball.

The antecedents-consequences model by Adler and Adler (1978) suggests that psychological momentum might be the cause of the change in performance. The current study does not support the model as it found no significant difference as to whether the previous shot outcome had any effect on the current shot outcome. The multi-dimensional model by Vallerand et al. (1988) suggests that psychological momentum can be explained by a “momentum chain“ which consists of six elements. In the current study we simply do not have evidence for that pathway and therefore it does not support the model. The projected performance model by Cornelius et al. (1997) states that positive and negative psychological

momentum are not the cause of performance changes but rather the results. Our findings did not provide enough evidence to support this model.

Limitations

The main limitation of the current study is the number of matches analysed. The time it takes to collect data from one basketball match takes 2 to 2,5 hours and 10 matches was considered enough to fit into the estimated hours to finish the project based on the ECTS's for it. Another limitation might be the shot efficiency in the women's basketball top-league in Iceland. When looking at successful shots from each location, no percentage of successful 2 point shots went over 50% in any location, which means that less than half of the 2 point shot attempts were unsuccessful (figure 3).

Conclusions

The results of the current study from analysing current shot outcome after the previous shot outcome was a score or a miss showed no significant difference when all the teams were analysed together. These findings agree with previous studies (Gilovich et al., 1985; Koehler & Konley, 2003; Lantis & Nesson, 2021). However, when the teams were analysed separately a significant difference was found for three teams and therefore momentum was detected.

All performance variables had significant influence on the current shot outcome. This is both in agreement (Vencúrik et al., 2022) and disagreement (Csapo & Raab, 2014) with previous studies.

The analysis of shot location based on the previous shot outcome found no statistical significance. There was however a considerable difference in location chosen for shots, both after missing and scoring the previous shot. Previous shot outcome did not affect any of the other performance variables for the current shot.

The results of the current study did not provide enough evidence to favour any of the theoretical models of momentum over the others.

Practical applications

Understanding momentum in sports can help improve performance of athletes. The results of momentum studies can provide coaches and players with objective data they can take into consideration when planning training sessions. Momentum can also be used to explain performance of athletes and even make predictions based on previous or ongoing performance of an athlete or a team (Briki, 2017).

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