Comment on ‘Forces on hockey players: vectors, work, energy and angular momentum Nina Nässén et al 2019 Eur. J. Phys. 40 065005’

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Abstract
Nässén et al (2019 Eur. J. Phys. 40 065005) are recommending a different hockey skating technique called ‘angular momentum skating’. The authors use examples of physics, and physics equations for work and energy of traditional forward skating strides. However, this information can be interpreted as a disguise for their different skating technique because the physics models and equations do not capitulate any justification for hockey players using their angular momentum skating technique. The authors suggestion to use an angular momentum skating technique is a judgement not founded on proof or certainty. They offer no objective proof, through physics equations or otherwise, that angular momentum skating has any benefits for hockey players to be faster, more efficient skaters.

Keywords: hockey skating physics, ice skating physics, hockey skating coaching, performance enhancement for hockey

1. Introduction
The authors provide equations to describe the physics of normal skating. But they do not provide the same proof for energy transformations, velocity, kinetic energy, and ground reaction forces for their ‘angular momentum skating’. Their entire proposal has no data-based proof.

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The authors indicate they are investigating a skating stride that has a longer gliding phase in a circular arc without the need for additional energy, and the conservation of angular momentum leads to increased speed as the centre of mass is shifted closer to the centre of the circular arc. Any time there is a longer glide phase in hockey skating, this will make a player slower [2–5]. It is curious why the authors would be interested in the physics of a skating technique that makes hockey players slower.

1.1. Nässén et al assumptions about alternative skating technique and incorrect citations

Nina Nässén and her co-authors start by indicating the following: ‘two of us (NN and HN) have worked as hockey trainers for many years and found that an alternative technique seems to offer comparable speed while requiring less energy from the skaters than traditional hockey strides.’ This is an assumption with no proof. In order to prove ‘angular momentum skating’ requires less energy, the authors need to provide data showing the physiology of lower energy expenditure and the physics of increased force being exerted by the skate blades on the ice which is transferred to horizontal velocity.

Nässén et al [1] make a dramatic error by citing Budarick, [6] quoting Marino [3] as saying ‘80% of a skating stride is spent in the single support, or gliding phase, and 20% in the double support, or propulsion phase.’ Wayne Marino did not write this in his paper. It is inappropriate for authors to use a quote of another author instead of citing the actual paper. What makes it worse is the author they cite misquotes the original paper.

The authors cite a promotional video [7] as a reference to understand the traditional skating stride. First, it is inappropriate to use a promotional video from a website as a citation. Second, the video [7] shows no reference to physics, angular momentum, and equations for work and energy.

1.2. ‘Angular momentum skating’, and ‘skating with circular arcs’

An increase in kinetic energy can be obtained by the production of force by the skates pushing into the ice, which accelerates the mass of a player from resting to maximum velocity. Once the body has gained energy during acceleration, the body maintains kinetic energy with repeated force production (the propulsion phase(s) of a stride [3, 5]). With circular arcs, a lot of kinetic energy would be lost during the extended glide phase. Angular momentum skating contradicts the law of physics, stating an ‘object in motion will remain in motion unless an external force acts on it’, because when a hockey player glides with no force application, he or she will slow down. We have known for many years that hockey players need to maintain their kinetic energy by increasing or maintaining their force production and reducing the glide phase of the stride. We have also known for many years that the longer the glide phase, the more waste of kinetic energy, making a player slower [2–5, 8].

Moreover, the authors’ skating technique, as demonstrated in their video, contradicts the law of physics which states ‘for every action there is an equal and opposite reaction’, because in their demonstrations, they do not have uniform action-reaction of the arms and legs. This would cause problems for hockey players: most importantly, they would be slower.

Hockey players avoid large sinusoidal movements when skating straight. Nässén et al’s [1] angular momentum skating accentuates sinusoidal horizontal movement, making it a slower skating technique. Speed skaters have large sinusoidal movements, but not hockey players. Horizontal force of the push-off skate is orthogonal to the motion of the gliding skate. But, in hockey skating (when skating straight) the centre of mass barely moves side-to-side because the force is applied rapidly and there is never a situation where the movement is in the centre of the circular arc.
In regard to the theories presented in the sections entitled ‘Angular momentum skating’, and ‘Skating with circular arcs’, the authors are demonstrating skating physics contrary to what research has found as the physics of fast hockey players [2–6]. The authors are quoted as saying ‘in this alternative technique, the change of direction requires no additional energy from the skater. Instead, the sideways force from the ice on a leaning skate is used to creating an arc where the direction changes continuously, without requiring work by the skater.’ It is impossible to say the change of direction, or changing direction continuously, requires no additional energy from the skater if they have not compared the energy expenditure, heart rate, rating of perceived exertion, VO2, and/or the component of the force being exerted onto the ice of the alternative technique with traditional skating.

The authors provide detailed information about the physics of skating in other parts of the paper. They give information about the angle of the average direction of motion, velocity using equations, and kinetic energy using equations. But they do not provide evidence using physics and equations when they theorise that angular momentum skating requires no additional energy, that the arcs do not require work by the skater, and that they can maintain their horizontal velocity.

Their statement about conservation of angular momentum and increasing speed as the radius of the circle shrinks again is a shroud of physics disguised to suggest that a hockey player would make a turn on one-skate with his or her shoulders abducted and held like a figure skater. No hockey player turns (or skates) like the authors demonstrate in the video.

Angular momentum skating also contradicts the physics law ‘force equals mass times acceleration’. During acceleration a force is applied to the ice by the skates which propels the mass of a player to accelerate. The player cannot accelerate his or her mass when gliding (circular arcs), which will cause the mass to slow down and the player will be a slower skater [9].

2. Conclusion

The authors have not met their objectives with this paper. Their concept of the ‘angular momentum skating’ technique is not a realistic example of the physics of skating because it would never be used for skating training or during a game. Nor is it a real-life example of the physics of skating because the skating technique presents movements that are never used by hockey players, and it contradicts the laws of physics.

The authors have not even taken the time to do a proper review of the literature to help physics students, and readers, understand what 45 years of research has shown as the physics of fast hockey players. This paper misleads people about the best way to improve skating. This paper does not adhere to the mandate of the European Journal of Physics: ‘assisting in maintaining and improving the standard of taught physics in universities and other institutes of higher education.’ The authors make incorrect, inaccurate, and unfounded conclusions about the skating technique they are promoting. This is an opinion paper. One must have a very limited understanding of the physics, biomechanics, and demands of hockey skating to propose a skating technique such as this.

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