

Full Title: Improving the reporting of tennis injuries: the use of time or workload data as the denominator

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## **Abstract**

Advances in technology have changed the way that we understand and consume sports performance. From an injury epidemiology perspective, the data generated from these technologies - particularly those related to player exposure or load - can also provide cause to reconsider accepted norms of how to report injury data. Using tennis as a case study, we highlight the opportunity for these new data to provide richer and more meaningful injury insights.

## **Discussion**

Historically, epidemiology researchers have identified bespoke units of measurement to express each sport's injury narrative. In 2009, respected industry professionals suggested that tennis injuries be reported per 1,000 player hours rather than athletic exposures (such as 1,000 matches) due to large variations in the time component of such exposures[1]. This goes some way to addressing the lack of uniformity in tennis injury data, which McCurdie et al. [2] have identified as the most significant challenge to understanding injury in elite tennis. However, given the streams of data now available, it seems timely to revisit whether this recommended choice of exposure remains as pertinent as it once was?

Gescheit et al. [3] recently highlighted how the choice of exposure can influence study conclusions. For example, when comparing female muscle injury rates using game exposures (strongly correlated to match duration) versus set exposures at the Australian Open between 2011-16, they found 14% variation in the number of reported injuries over time. This finding, as with the initial recommendation from Pluim et al. [1], support the selection of an exposure measure that represents the smallest common unit of matchplay, which may vary depending on the population of interest (professional vs junior) and technology accessible (Hawkeye vs match clock). Furthermore, given that the injuries sustained in tennis are a direct result of the mechanical loads imposed on the musculoskeletal system [4, 5], it seems intuitive to consider different denominators in determining the rate of injury for different parts of the body. For example, some measure of ball striking should logically feature in an upper limb/body exposure and distance run might be a more appropriate exposure measure for the lower limb.

We analysed a subset of Gescheit et al. [3] data and aligned it with real-time multi-camera ball and player tracking (HawkEye data) from the corresponding professional tennis matches. The subset included absolute injury counts, while the HawkEye data included hitting volumes (the number of serves, groundstrokes and volleys played by both players), movement distances (the combined distance traversed by both players when the ball was in play) and durations (match time). A linear model was fit to each 2-way combination of exposure measures (duration-hitting volume, duration-distance, distance-hitting volume) and we examined the choice of exposure related to the strength of association (explained by variation from the  $r^2$  statistic in a linear regression).

\*\*\* Insert Figure 1 here \*\*\*

\*\*\* Insert Table 1 here \*\*\*

Match duration was only moderately related to hitting volume ( $r^2 = 0.37$ ) and match distance ( $r^2 = 0.30$ ), with only 37% and 30% of the respective variance explained. This questions the use of match duration as the gold standard measure of injury exposure at the professional level. Indeed, while match duration may hold some value in comparing gross injury trends between populations or represent the most pragmatic injury exposure measure for many junior or recreational tennis populations (where technology is constrained), it has limited utility in describing injury relative to the physical demands of professional tennis.

There was a much stronger association between match distance and hitting volume, our proxies for lower and upper limb load. We believe that this can be interpreted in two ways. First, it might be that the lower and upper limb load in tennis are strongly correlated. Second, it may be that neither exposure measure adequately captures the intensity of the movement or stroke, which logically relates to joint loading and deserves further enquiry. Either way, these points reinforce the importance of selecting an exposure measure (denominator) based on the numerator of interest, which in our view, is often overlooked or oversimplified in tennis research. Although not something that we have entertained here, taken further, the type (joint v muscular) or mechanism (acute v chronic) of injury may even influence the denominator chosen.

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95 So, how should tennis researchers report injury in the future? Fundamentally, the choice of  
96 exposure method needs to be tailored to the research question of interest, the population and  
97 technology available. To that end, our work here shows that the current norm of reporting injury  
98 rates relative to match time provides limited insight and should be reconsidered at the  
99 professional level. New workload data are promising in this regard as they may serve as  
100 denominators to more precisely inform the tennis injury debate.

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**Table 1: Description of the strength of the associations between the different exposure measures**

Match variable 1	Match variable 2	$r^2$	$\sigma^2$
Match distance	Total shots	0.93	60.21
Match duration	Total shots	0.37	37.51
Match duration	Match distance	0.30	39.61