

## Objective assessment of knife sharpness over a working day cutting meat

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### ABSTRACT

Knife sharpness is one of multiple factors involved in musculoskeletal disorders in industrial meat cutting. The aim of this study was to objectively evaluate, in real working situations, how knife sharpness changed over a working day cutting meat, and to analyse the impact of sharpening, steeling and meat-cutting activities on these variations. Twenty-two meat-cutting workers from three different companies participated in the study. The methods included measurements of knife sharpness in relation to real work situations and consideration of the way meat-cutting and sharpening operations were organised. Results showed that the type of meat-cutting activities, the steeling strategy adopted by the worker, including the types of tool used, and the overall organisation of the sharpening task all had a significant influence on how knife sharpness evolved over a 2-h period and over an entire working day. To improve MSD prevention, sharpening and steeling operations should not be considered as independent activities, but taken into account as a continuity of working actions. Appropriate assessment of knife sharpness by meat cutters affects how they organise meat-cutting and sharpening tasks.

### 1. Introduction

In Europe and France, musculoskeletal disorders (MSD) are one of the most widely-recognised types of occupational disease (EUROGIP, 2015). As a result, prevention of MSD is a European research priority for 2020 (EU-OSHA, 2013). All occupational sectors are affected by MSD, and particularly the meat-cutting industry in France (CNAMTS, 2016). Meat-cutting activities combine numerous MSD risk factors, including repetition, force, static posture, low temperature, work organisation, and lack of recovery time (InVS, 2007; NIOSH, 1997; Roquelaure et al., 2006; Silvin, 2000; Tappin et al., 2006; Vézina, 2008; Vogel et al., 2013). These risk factors are themselves influenced by various environmental factors (Tappin et al., 2008), including tight and immovable deadlines as well as piecework (Nossent et al., 1995), the properties of the meat (Claudon and Marsot, 2003), the experience and ability of the meat cutter (Karlton et al., 2016; Major and Vézina, 2015; Vézina et al., 1999) and knife sharpness (Bishu et al., 1996; Claudon and Marsot, 2006; Dempsey and McGorry, 2004; Karlton et al., 2016; Savescu et al., 2013; Szabo et al., 2001a, 2001b). All of these factors interact to determine the dynamics of MSD occurrence.

Biomechanical factors have been identified in meat-cutting operations (Karlton et al., 2016), and are important, in particular when the knife is “cutting badly”. McGorry et al. (2003) observed that the mean cutting moment increased by 25% with a dull knife (McGorry et al.,

2003). The knife's cutting ability is influenced not only by intrinsic parameters, such as the shape (straight or curved), length (different lengths for different operations) and steel composition (different proportions of chemical components to give different steel hardness) of the blade (Jacqmin and Marsot, 2004; Karlton et al., 2016), but also by maintenance operations such as sharpening and steeling, and the conditions in which these are performed (Ouellet and Vézina, 2014; Vézina et al., 2008a, b; Vézina et al., 2000). Sharpening is represented by all of the operations performed using various machines to hone the cutting edge of a knife, which is considered to be its initial sharpness prior to cutting operations. Sharpening operations are always performed outside the meat-cutting work area. The other maintenance operation, steeling, helps to maintain the initial sharpness and prevents dulling. This operation is carried out within the meat-cutting work area using different tools (a steeling rod or a steeling device with crossed bars). Steeling operations are performed between meat-cutting operations (Vézina et al., 2008a). To gain a better understanding of the influence of different parameters on knife sharpness, studies have attempted to assess knife sharpness objectively using a measurement system (Claudon and Marsot, 2006; EN ISO 8442-5, 2002; Karlton et al., 2016; Marsot et al., 2007; McGorry et al., 2003, 2005; Szabo et al., 2001a). Most of these studies were conducted under laboratory conditions and only a small number (Karlton et al., 2016; Szabo et al., 2001a) were carried out in real working situations, but imposing certain

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experimental conditions (e.g. use of a specific knife). Indeed, Karlun et al. (2016) compared the impact of the quality of the steel in the knife blade relative to the meat cutters' individual ability to maintain the sharpness of the knife using new knives. One of their conclusions was that, regardless of the steel from which the knife was forged, the ability to maintain a sharp cutting edge differed significantly between individual meat cutters, both in terms of edge wear and the time for which each knife was used.

However, even if the meat cutters' skill level incontestably influences knife sharpness, we have limited knowledge of how knife sharpness evolves over a working day and the impact of each operation (meat-cutting activities, steeling, sharpening) and various factors influencing these operations (sharpening organisation, steeling tool strategy). There is therefore a real need to gain more in-depth knowledge of how these operations and factors contribute to knife sharpness in order to identify action levers for MSD prevention. The present study is part of a larger study analysing meat-cutting activities and knife maintenance activities, including objective and subjective assessment, in a sub-contracting context. The aim of this paper was to present how knife sharpness evolves over an actual working day using objective assessment, and to analyse the impact of sharpening, steeling and meat-cutting activities on this evolution.

## 2. Materials and methods

### 2.1. Participants

The knives and activities of a total of 22 meat cutters were analysed. All participants had previously been informed of the aims and content of the study and had given their written consent for participation. Individual data for the meat cutter participants, presented in Table 1, were collected during short interviews held outside the meat-cutting workplace.

Participants worked for three different sub-contractor companies (SC), at three different production sites (A, B, C). All three SC were specialised in pork meat cutting. Knife sharpening operations were organised in three different ways in the companies studied, with the sharpening performed by: (1) the sub-contracted meat cutter (i.e., an individual employed by the SC - ISC); (2) one sub-contracted sharpener for all sub-contracted meat cutters (i.e., centralised by the SC - CSC); (3) three sharpeners from the contracting company for all sub-contracted meat cutters (i.e., centralised by the contracting company - CC).

### 2.2. Knife sharpness evaluation (KSE)

The KSE measurement system used in this study was originally developed for meat-cutting activities (Marsot et al., 2007), and was previously used in laboratory conditions (Claudon and Marsot, 2006). The system measures the total force (normal and tangential forces

**Table 1**

Personal characteristics (age and experience as a meat cutter) for participants in this study, and organisation of sharpening activities in their workplaces. Data are shown as mean and standard deviation at each meat-cutting site (A, B, C). The number of participants for each site is presented with the specification of their principal activity during data collection (deboning or trimming).

Site: organisation of sharpening operations	Number of participants (Deboning/Trimming)	Age in years (Mean (sd))	Experience as meat cutter in years (Mean (sd))
A: ISC	n = 10 (5/5)	39 (10)	13 (9)
B: CSC	n = 6 (4/2)	41 (7)	18 (10)
C: CC	n = 6 (1/5) <sup>a</sup>	39 (8)	19 (9)

<sup>a</sup> The mean and standard deviation were calculated for 5 participants. One of the participants provided no personal information but agreed to participate in the rest of the study.

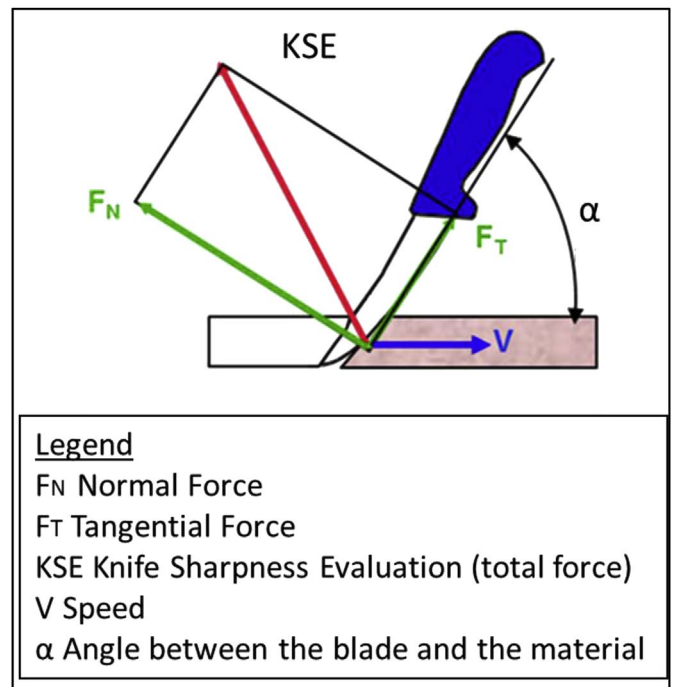


Fig. 1. Method used to measure KSE.

( $KSE = \sqrt{FN^2 + FT^2}$ ) exerted by the knife while cutting (speed  $v = 50$  mm/s) a standardised material (foam rubber: thickness = 40 mm) (Fig. 1). The angle between the blade and the material was 30°. The standardised material was used to avoid variability in meat toughness (due, for example, to the age of the animal, type of cut meat, temperature, etc.) and to comply with hygiene rules. The force measured is inversely related to knife sharpness: the higher the force (KSE), the less sharp the knife, and the less it can cut. Previous studies indicated that if KSE exceeds 40 N, the knife needs to be sharpened.

The KSE of each knife was measured at the tip extremity of the blade. The mean resultant force of three consecutive measurements was taken to represent the KSE of each knife. The knives were not new, and were those commonly used by the meat cutters. The length (mean L (deboning) = 120.42 mm (SD = 13.19 mm); mean L (trimming) = 142.21 mm (SD = 32.78 mm)) and the width (mean W (deboning) = 12.87 mm (SD = 1.98 mm); mean W (trimming) = 14.41 mm (SD = 3.58 mm)) of blades were measured for 64 knives using an electronic calliper. The width was measured mid-way along the blade. These measurements were made before sharpening, when the first KSE was recorded.

### 2.3. Data-collection method

For all sites, data were collected according to a defined procedure (Fig. 2) related to the real work situation and taking the organisation of meat-cutting and sharpening operations into account. In this procedure, the knife was tracked and KSE was recorded at different times during the working day. This allowed analysis of the activity of different workers (sharpening workers or meat-cutting workers). The different steps in the procedure were as follows (Fig. 2):

1. KSE of all knives that each meat cutter had in his possession was measured before the start of the working day (usually 3 or 4 knives for each meat cutter) and before sharpening operations ( $KSE_i^0$ , where  $i = \text{number of knives} = 64$ ).
2. Knives were sharpened.
3. KSE of all knives was measured after sharpening ( $KSE_i^1$ ).
4. The meat cutter worked for at least 30 min before recording any

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