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Maintaining knife sharpness in industrial meat cutting: A matter of knife or meat cutter ability

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ABSTRACT

Knife sharpness is imperative in meat cutting. The aim of this study was to compare the impact of knife blade steel quality with meat cutters' individual ability to maintain the cutting edge sharp in an industrial production setting. Twelve meat cutters in two different companies using three different knives during normal production were studied in this quasi-experimental study. Methods included were measuring knife cutting force before and after knife use, time knives were used, ratings of sharpness and discomfort and interviews. Results showed that the meat cutters' skill of maintaining sharpness during work had a much larger effect on knife sharpness during work than the knife steel differences. The ability was also related to feelings of discomfort and to physical exertion. It was found that meat cutters using more knives were more likely to suffer from discomfort in the upper limbs, which is a risk for developing MSD.

1. Introduction

Accidents and musculoskeletal disorders (MSDs) are since long frequent among meat cutters, both in Sweden (Arbetsmiljöverket, 2012; Magnusson et al., 1987) and elsewhere (Conroy, 1989; Coutarel et al., 2004; Tappin et al., 2006). The risk/1000 employees for serious occupational injury were 15.8 for employees in slaughterhouses and meat processing compared to 2.3 for all blue collar workers in Sweden.[1] The most common accidents among meat cutters are related to the knife (Cai et al., 2005) where the fingers are at greatest risk.

Moreover, several studies have shown how knife sharpness affects the meat cutters' work load and thereby risk for MSDs (Bishu et al., 1996; Claudon and Marsot, 2006; Dempsey and McGorry, 2004). Carpal tunnel syndrome and trigger finger are more prevalent among meat cutters than other industrial workers and are suspected to be caused by hand held tools as knives (Gorsche et al., 1998, 1999). Among meat cutters, MSDs regarding other upper-limb joints such as e.g. epicondylitis and tenosynovitis (Kurppa et al., 1991; Viikari-Juntura et al., 1991), tendonitis (Yassi et al., 1996), neck and low back pain (Magnusson et al., 1987) are problematic. For a more comprehensive review, see Tappin et al. (2006).

A sharp knife thus means lower grip force, cutting moment and cutting time (McGorry et al., 2003). When the knife is dull, the forces involved are higher which increase the risk for MSDs. In the study of McGorry et al. (2003) the mean cutting moment increased with 25% when the knife was dull. Moreover, the wrist will be pressed to deviate which may lead to epicondylitis (Claudon and Marsot, 2006). Consequently, according to literature a sharp knife is of high importance to avoid accidents and MSDs. It is the sharpness of the knife in use that determines the workload, cutting forces and usability of the knife. So what are then the factors that may influence the sharpness of the knife during cutting?

The sharpening itself at a grinding machine determines the initial sharpness of the knife when beginning to cut. Sharpening is however not included in this study as this is not performed during cutting work but as a separate activity that is organized differently depending on size of company and organizational choice.

The quality of the steel in the knife blade has an impact: in a test of three different steel qualities the blade material did not have any initial effect on cutting capacity, but the harder the steel the better

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[1] Official statistics from the Swedish Work Environment Authority, 2014/12/31. Available on request.

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the knife retained its sharpness during repeated wear by striking the edge to a brass cylinder (Marsot et al., 2007). However, no tests of steel quality impact during real meat cutting have been published and it is thus unclear whether the repeated wear towards a brass cylinder corresponds to the situation in real work.

The other possible impact on knife sharpness during cutting is the individual working technique, which in turn can be separated into avoiding dulling the knife and maintaining the sharpness. Regarding the latter, when using a knife, the hair thin cutting edge gets wavy and bent and a technique called steeling is used for retaining a sharp edge. Steeling restores the edge by straightening and re-centring it and this is made by swiping the knife edge along a steel rod or through a steeling device with crossed bars (Dick, 2014; McGorry et al., 2005b; PRIMEdge, 2015; Szabo et al., 2001). Steeling is made during work as a separate activity in between cutting the meat and meat cutters spend up to 10% of their work time steeling their knife (CINBIOSE UQAM, 2008). Being skilful in steeling is considered to be difficult but essential for keeping a knife sharp.

The other aspect of the individual meat cutter's impact on knife sharpness is less described in literature. Experienced meat cutters and supervisors claim that cutting in the bones, touching the protective metal mesh gloves or apron with the edge or cutting into the cutting board are typical situations when knives become dull. However, more detailed knowledge about the individually related mechanisms does not exist, nor does knowledge regarding the magnitude of the impact of individual skill in relation to knife steel impact exist. There are however indications from knife manufacturers and people working in the business that the differences between individuals in ability to keep their knives sharp are large. Such indicators are for example how often a meat cutter has to sharpen the knife or how many knives are used during a day.

In their study of work training in meat cutting, Ouellet and Vézina (2014) found that cutting quality of the knife was perceived most important by the experienced workers regarding numbers of cuts required to perform a task and the apprentices in the study identified the knife as being the most important factor of 12 regarding pain at work.

It is therefore of vital importance to shed more light into the factors that affect the sharpness of the knives used when cutting, not the least in order to find opportunities for reducing the work load of meat cutters. The aim of this study was thus to compare the impact of the quality of the knife blade steel in relation to the impact of the meat cutters' individual ability in maintaining the sharpness of the knife. A further aim was to investigate to what extent the individual ability to maintain knife sharpness can be related to the individual meat cutter's experiences of discomfort, exertion and knife sharpness.

2. Material and methods

The study was performed as a quasi-experimental case study in two separate meat cutting companies. Both companies cut beef, were privately owned and each plant had some 50 employees of whom 10 were employed as meat cutters doing deboning, starting with quarter carcasses. Six participants (Table 1) in each plant volunteered and gave their informed consent. All were men with more than 2 years' experience as meat cutter.

2.1. Work procedures

Work consisted of cutting beef from quarters of carcasses brought to the meat cutters hanging on a roof conveyor. One working cycle consisted of cutting a quarter carcass and took approximately 10 min. Additional work was knife steeling (maintenance) and sliding of quarter carcasses to their work stations. The weekdays Tuesday to Thursday in one week per plant were chosen in order to certify that conditions would be as uniform as possible.

Work periods and breaks are shown in Fig. 1. Breaks lasted 15–45 min and were spent sitting in rest or canteen rooms, close to the work stations. Total working time at A was 7 h, and 8 h at B.

2.2. The knives

A standard model of knife was used but with three different steel qualities in the blades (Fig. 2).

One was a prototype (P) with a nitride hardened steel blade; one was from a Swedish manufacturer (S) and one from a French manufacturer (F), both using traditional but slightly different carbide hardened steel. All being 150 mm long and semi-flexible and hardened to HRC 57–59. The knives were chosen for being the most common standard design used for this type of deboning according to the Swedish manufacturer. They were as similar as possible in appearance but using different steel manufacturers. The participating meat cutters normally used similar knives. The study also provided an opportunity to test a steel quality not previously used for hand-held knives. All knives in the test were new and sharpened with an angle of 35° in a standardised way by an independent company only performing sharpening of tools and using Cozzini PRIMEdge centralized knife sharpening system (PRIMEdge, 2015). All participating meat cutters used X-steels for maintaining the edge during experiment.

2.3. Methods for data collection

Data were collected through interviews, ratings and measurements of knife sharpness and time each knife was used. The procedure for each data collection and the analysis performed is described below.

2.3.1. Procedure

Short interviews were initially held with all meat cutters included in the study. Apart from collecting the individual data displayed in Table 1 the interviews covered knife related experiences as their opinions of knives, sharpness and steeling. They were also asked how they would describe the feeling of cutting with a sharp or dull knife respectively, and questions related to knife sharpness training experiences. The interview data was grouped into categories and representative answers and opinions are provided in the results section to show how meat cutters express the experiences related to the quantitative results.

The rest of the data was collected following a defined procedure related to the meat cutting work performed. In each company, Tuesday-Thursday was used to make sure that the carcasses only had been chilled for one night which affects the hardness of the meat and to avoid “Friday rules”, being common and deviating work procedures in order to prolong the weekend.

1. The procedure was planned so that each meat cutter was assigned three knives of the same type for each day of participation. Knives and meat cutters were paired randomly. Each day, two participating meat cutters used knife type F, two used type P and two used type S. The order in which the knives were assigned was balanced.
2. Before each meat cutter started working in the morning he was given a numbered freshly sharpened knife by the researchers. This knife had already been tested for its individual sharpness. Each meat cutter also rated their morning discomfort before starting to work according to the rating procedure described