AN INVESTIGATION INTO FATIGUE PREVALENCE AMONGST CITRUS PACKHOUSE SORTERS IN THE EASTERN CAPE PROVINCE OF SOUTH AFRICA

BY

HARRY ROBINSON

(ORCID number: 0000-0001-6655-4020)

THESIS

Submitted in fulfilment of the requirements for the degree of Master of Science

Master of Science: Human Kinetics and Ergonomics

Department of Human Kinetics and Ergonomics

Rhodes University, 2023

Makhanda (Grahamstown), South Africa

ABSTRACT

Background: South Africa is the second most influential exporter of citrus fruits internationally and holds a pivotal role in economic revenue for the country. Rural areas, such as the Sundays River Valley in the Eastern Cape province of South Africa, contribute to the country's citrus production. Many women depend on citrus packhouses for employment as citrus sorters. As humans perceive certain defects in citrus fruits more accurately than machines, these sorters must identify and manually remove any fruit that does not conform with export requirements. Citrus sorters are exposed to numerous physical and cognitive stressors during the task while faced with organizational challenges, such as shift work and long working hours. Therefore, the potential for fatigue development is anticipated. Given the multifactorial nature of fatigue and the negative consequences it may have on workers, it also has the potential to impede the accuracy of the sorting performance. Stringent disciplinary action for the entire South African citrus industry may be of consequence if non-conforming or pest-infested fruit is missed by citrus sorters and exported to foreign countries. This study aimed to investigate the prevalence of fatigue among citrus sorters in a citrus packhouse in the Sundays River Valley of the Eastern Cape throughout a citrus harvesting season and to identify factors that may contribute towards fatigue development. **Methods:** The research design utilized a cross-sectional, two-part approach that applied mixed methods. Part one was administered once-off, incorporating demographic, work-, and non-work-related questions. Part two was a self-developed repeated measures assessment comprising close-ended contextual questions, the Modified Fatigue Impact Scale, and the Karolinska Sleepiness Scale. Environmental and work output data were also recorded. **Results:** Citrus sorters (n= 35) recorded a mean MFIS score of 39.35 throughout the harvest season, which was above the prescribed fatigue threshold (38). However, there was no significant difference in fatigue ratings over time (p= 0.122). Day shift workers exceeded the fatigue threshold for the entire season compared to night shift workers, who only exceeded it in the last two weeks. The physical, cognitive, and psychosocial subscales found no significant difference in fatigue scores, although physical fatigue recorded the highest scores across all weeks and displayed a significant difference over time. Overall, participants, on average, perceived to be "neither sleepy nor alert" over the season. However, eight participants (22%) recorded sleepiness scores exceeding the excessive sleepiness threshold of seven. Educational levels, health status, work-pace, and the number of family dependents significantly contributed to fatigue development, albeit a weak correlation. **Discussion:** Sorters were perceived to be fatigued from week three till the end of the study; however, there was no variation in fatigue scores over time. An accumulation of physical fatigue over time was revealed where prolonged standing, repetitive work, and irregular working postures may have contributed. Night shift workers did not receive the recommended hours of sleep (7-8 hours); hence, they registered greater sleepiness scores over the season than day shift workers. Environmental and work output recordings did not prove to have a significant influence on fatigue development, and neither did work experience or physical exercise. **Conclusion:** An amalgamation of numerous contributing factors within the work situation, private situation, and the individual influenced the development of fatigue, where there was no primary causal factor. Future studies should consider recording the accuracy of the sorting performance to acquire rich, objective data.

Key words: fatigue; citrus sorters; shiftwork; sleepiness

DECLARATION

I declare that this thesis is my own, unaided work. It is being submitted for the Degree of Master of Science in Human Kinetics and Ergonomics at Rhodes University, Makhanda. It has not been submitted before any degree or examination in any other University.

. . . .

Harry Robinson

. . . . 9 . . . . day of . . August 2023 . . . .

ACKNOWLEDGEMENTS

"*The last three steps*."

First and foremost, I would like to give a HUGE thank you to my supervisor, Miriam Mattison, for your continuous support, guidance, patience, and considerable effort you placed into this research. Working with you over the past few years has been an honour, and I will dearly miss our weekly meetings and writing sessions.

The HKE department has been considered my "home away from home" for the past few years, where the most incredible staff members and students have accommodated and helped me throughout my academic career. Thank you to everyone who has contributed. I could not have asked for a more amazing department.

A special thanks to Citrus Research International for the guidance you gave me at the start of this research.

To the packhouse management and supervisors, thank you for your assistance and cooperation in making this research happen. Your constant friendliness made it such a pleasure working alongside you. All the best.

A special mention to all the participants involved in this study, who willingly provided me with their limited time to answer all surveys throughout the citrus season. This research study would not have been possible without your commitment, patience, and trust in me. I am forever thankful and acknowledge the massive influence your work has on such an important industry.

To my fellow masters' peers, our writing circles, banter, and consistent support will never go unnoticed. So much love for you all!

Lastly, a special thank you to my family for the love you supplied me with and for always believing in me. I would not be where I am today without you all by my side.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

1.1. BACKGROUND TO THE STUDY

The modern-day agricultural sector is exposed to an ever-increasing globalized trade market, and it has become increasingly challenging for producers to remain competitive in the global market (Dlikilili & Van Rooyen, 2018). Since 2004, the South African citrus industry has been the second most influential exporter of fresh citrus to foreign markets, even though South Africa is only the 10^{th} largest producer of citrus internationally (Citrus Growers Association, 2020). Of the fruit harvested by the citrus industry, more than 65% is exported to the international markets, less than 30% is processed for juicing, and the remainder is supplied to the local markets (Citrus Growers Association, 2021). 2020 saw the largest shipment of citrus production ever, as more than 146 million crates of citrus were exported. This number is expected to rise over the next couple of years as new international market routes to China and the Philippines have opened, and younger trees have entered their production stage (Citrus Growers Association, 2019; Stoddard, 2021). This record export trade in 2020 translated into an estimated total profit from foreign revenue of over R20 billion, highlighting the apparent export demand and the economic importance of this industry to the South African economy (Smith, 2021). In addition to the high demand for fresh citrus fruits, consumers demand more than just variety and quantity; they desire quality, consistency, and value (Ndou & Obi, 2015). Therefore, importing countries have established stringent regulations that govern food safety and health standards to safeguard the consumer of traded food items (Ndou & Obi, 2015). These regulations dictate that exported fruits should be free of damages caused by low temperatures and wind, blemishes, cuts, diseases, and misshapen proportions (Bollen & Prussia, 2014; Ndou & Obi, 2015). Most importantly, these regulations require established phytosanitary treatments that eliminate, sterilize, and kill any pests that may potentially infect exported fruits and prevent their introduction into new areas, as well as protect consumers' health and safety (Follett & Neven, 2006). Remaining competitive in the international market is essential for the future growth of the South African citrus industry. However, the industry will be unable to maintain its financial performance or consider further development if it does not produce and sell quality fruits that conform with international regulation standards and policies (Dlikilili & Van Rooyen, 2018).

The function of the citrus packhouse is to transform the fruit received from the harvesting operations into marketable products for shipment that conform with the customer's requirements and governmental regulations for export (Bollen & Prussia, 2014). The packhouse is designed as a highly automated and technological process system; however, the sorting table in the packhouse is one of the few sites that still require human interaction for manual inspection of all citrus fruits (Studman, 1998). The sorting table is pivotal in the packhouse processing system as it is the last inspection safeguard to eliminate sub-standard fruits destined for export. Additionally, sorting is a critical stage in the systems approach for phytosanitary management of citrus fruits destined for export so that pests and infections are not introduced into foreign countries or contaminate other fruits in the system (Hattingh et al., 2020). The tasks at the sorting table require the removal of fruits that do not conform with export standards and must therefore be eliminated from the supply chain. This is the responsibility of the sorters at the sorting tables. Automation for the sorting process has been implemented in developed countries as this technology offers significant advantages over manual sorting operations (Bollen & Prussia, 2014). However, these automated operations are incredibly costly, and most developing countries opt for manual sorting operations.

Furthermore, humans have a unique ability to perceive defects in the external appearance of fruits and determine whether the threshold exceeds the recommended grade for export standards (Bollen & Prussia, 2014; Nicolaï et al., 2014). However, these quality defects and pest infestation blemishes vary in size and can range from easily detectable to minuscule. Sorters may therefore miss non-conforming fruit if their ability to detect these is negatively affected. In addition to missing non-conforming fruit, sorters may also potentially reject fruit from the system, although the fruit conforms to the export standards and could have been sold at a higher rate.

Within South Africa, the Sundays River Valley, located in the Eastern Cape province, is considered one of the significant regions for citrus production (Meintjes, 2018). The area provides satisfactory growing conditions for citrus production and is regarded as one of the powerhouses in South African citrus production (SA Fruit Journal, 2009). With the Sundays River Valley being surrounded by farming communities, numerous packhouses operate within the Sundays River Valley, which provides significant employment for the area. It is estimated that ±25 000 residents in the Sundays River Valley are dependent on the citrus industry for employment, which is vital as the Eastern Cape province has statistically one of the highest unemployment records in the country, particularly amongst females (Meintjes, 2018; Eastern Cape Socio-Economic Consultative Council, 2021). Additionally, in 2016, an estimated 34 200 residents in the Sundays River Valley lived in poverty, where 61.73% were black Africans (Eastern Cape Socio-Economic Consultative Council, 2017). This highlights the challenging living and social conditions that residents within the Sundays Valley reside in, where these private situation stressors may further influence potential work-related fatigue.

It is evident from the literature that fatigue has been a concern within industrial workplaces for many decades, as fatigued workers report reduced productive time more than twice as often than those without fatigue (Grandjean, 1979; Lu et al., 2017). Fatigue is one of the most common complaints by workers within occupational settings worldwide, and there is increasing awareness of the impact that fatigue has on individuals' well-being and operational performance (Kant et al., 2003). Symptoms of fatigue, including mental exhaustion, reduced physical strength, discomfort, and lassitude can impair efficient human performance if recovery from fatigue is insufficient (Saito, 1999; Williamson et al., 2011). Fatigue symptoms can intensify over time if rest and recuperation are unsatisfactory. Fatigue is a complex multi-dimensional construct due to various interacting factors within and outside of the workplace, and its symptoms can manifest in many different forms (Yazdi & Sadeghniiat-Haghighi, 2015). Citrus sorters are exposed to task and work-related factors that may potentially generate the development of worker fatigue. These factors include prolonged standing, repetitive and monotonous tasks, shiftwork, long working hours, and sustained attention. These workers already endure challenging non-work-related elements, which may negatively affect the recovery process if fatigue exists. Thus, these manifestations of fatigue that induce decreased human performance can be detrimental to an occupational setting where human performance plays a significant part in the constructive functioning of the operating system, such as the citrus packhouse.

From an occupational health and safety perspective, all types of fatigue must be managed due to their significant short-term and long-term implications on workers' well-being and performance (Sedighi Maman et al., 2017). With the sorting station serving as an essential facet of the postharvest supply system, deviations and missed errors in the inspection process will affect returns for the company and potentially damage the reputation of the South African citrus industry. It is, therefore, necessary to ensure that factors that affect the worker's work capacity, such as fatigue, and thus the sorting operation are minimised so that the sorter can attain their best performance for the entire citrus season.

1.2. STATEMENT OF THE PROBLEM

The citrus industry is an essential contributor to the economy in the Eastern Cape province of South Africa, particularly the Sundays River Valley. The Sundays River Valley depends on the economic benefits that emerge from citrus fruits' production and commercial trade. The industry within the region provides immense employment opportunities, particularly for women who are the predominant workers within citrus packhouses and specifically at the citrus sorting stations. The sorting process requires attention to detail by ensuring that all non-conforming fruits are discarded from the packing line destined for export. Sorters' accuracy must be consistent throughout a harvesting season, as non-conforming fruit that is missed and packaged for export may result in detrimental consequences for the Sundays River Valley and the South African citrus industry. However, it is anticipated that the sorters within the citrus packhouse may experience symptoms of fatigue, given their exposure to various work-related and non-work-related factors. This may influence fatigue development, which may impact the workers' sorting performance. Given the physical and cognitive nature of the work, it is unknown how fatigue may manifest itself and how fatigue develops throughout the harvesting season.

To the author's knowledge, no previous academic studies have focused on the sorting process of citrus sorters working in packhouses within South Africa. However, previous research studies on orange handling operations in Nigeria and apple sorters working in the United States of America found that the most common discomfort experienced by workers was lower back pain and shoulders (Simcox et al., 2001; Lawan et al., 2018). When workers are exposed to tasks requiring repetitive exertion and high work demand, discomfort in workers' muscles may be an indicator of physical fatigue, and the risk of musculoskeletal disorders increases (Kilbom et al., 1996). From initial walkthroughs of several citrus packhouses and from what has been researched on the contributors towards fatigue it is expected that citrus sorters may experience an increase in fatigue levels throughout a citrus harvesting season. Determining the prevalence of fatigue among sorters working in the citrus industry as well as potential contributing factors, is an essential first step towards identifying appropriate and necessary interventions to create safeguards for the impact of fatigue outcomes if prevalence is of a high level (Lu et al., 2017).

1.3. PURPOSE OF THE STUDY

Given the negative consequences that fatigue could have on the worker and the overall work system, this study aimed to investigate the prevalence of fatigue among citrus sorters in a citrus packhouse in the Sundays River Valley of the Eastern Cape, South Africa, throughout a citrus harvesting season. To accomplish this aim, the objectives were to:

- Determine the prevalence of fatigue.
- Monitor changes in fatigue amongst sorters throughout the citrus harvesting season.
- Identify what fatigue domain (physical, cognitive, psychosocial) dominated.
- Determine any differences in fatigue levels between day and night shift sorters throughout a citrus harvesting season.
- Identify any associations between fatigue, individual, and work-related factors.

CHAPTER 2: REVIEW OF LITERATURE

2.1. THE SOUTH AFRICAN CITRUS INDUSTRY

The South African citrus industry has since long been one of the world's most influential citrus exporters, where the first introduction to the export market began in 1907 (Chisoro-Dube & Roberts, 2021). This industry has been exporting its fruit annually since and achieved its first milestone in 1925 when it exported over a million citrus fruit crates. Its exponential growth led to a single organisation, 'Outspan', coordinating all of South Africa's citrus exports in 1937 (Citrus Growers Association, 2007) and established the foundations for citrus production and distribution in South Africa. The single-channel marketing system provided the industry with considerable advantages; for example, it introduced numerous nurseries across the country, created packing facilities, developed research laboratories, and had prominent relationships with international markets (Larsen & Fold, 2008). However, due to anti-apartheid campaigns and deregulation, Outspan lost its exclusive control over citrus exports, and as a result, independent agencies were allowed to apply as export agents (Citrus Growers Association, 2007). The effects of deregulation reorganised the structure of the South African citrus industry as it progressed from a single-channel marketing system to the rise of private regulation allowing for numerous export traders. Deregulation also led to the formation of the Citrus Growers Association (CGA) in 1997 to manage research projects on behalf of all citrus growers, which in turn shifted the focus of citrus distributions from volume to quality concerning market demands (Genis, 2018). The CGA's mandate was to gain and retain market access, set standards for fruit and quality, fund and control research in this sector, drive industry transformation and represent growers for all industry stakeholders (Genis, 2018). Food security and food safety remain essential considerations for the quality assurance of citrus fruit so they can be successfully exported to international markets.

The goal of the citrus industry is for all fruit to be destined for export as this is more profitable than compared to local market prices. Of the fruit harvested by the citrus industry, more than 65% is exported to international markets, 29% is processed for juicing, and 6% is supplied to local markets (Citrus Growers Association, 2021). Compared to other citrus-growing countries, South Africa is only the 10th largest producer of citrus fruit. However, in terms of exporting, South Africa is the most influential citrus exporter in the southern hemisphere and the second most influential internationally behind Spain since 2004 (Citrus Growers Association, 2020). The citrus industry generates a considerable contribution towards the South African gross domestic product, where in 2019, over R20 billion rands were earned (Citrus Growers Association, 2020). Of the revenue that is generated by the citrus industry, the exportation of citrus accounts for about 85% (Citrus Growers Association, 2020). Furthermore, the citrus industry is estimated to be one of the largest employers within the South African agricultural industry as it accommodates approximately 125 000 people, with the bulk of workers employed in orchards and packhouses (Citrus Growers Association, 2017). This figure does, however, not include employees working upstream and downstream of the industry (e.g., nurseries, port handlers, transportation, and researchers). It is thus estimated that over a million households depend on the citrus industry for employment (Mogala, 2015).

In terms of citrus production, the Eastern Cape province is the second largest producer in South Africa, responsible for over 25% of the country’s citrus yield (Citrus Growers Association, 2022). The Sundays River Valley (SRV) region is one of the powerhouses of the Eastern Cape citrus production and accounts for a significant proportion of the country’s export commodity (Meintjes, 2018). This is attributable to the SRV region’s highly reliable water source, warm weather conditions and proximity to coastal ports for rapid transportation (SA Fruit Journal, 2009). Over 60 000 people live in the SRV, of which around 3 000 are employed permanently on citrus farms, approximately 15 000 are seasonal farm workers, and about a further 8 000 are employed within the valleys’ numerous packhouses (Meintjes, 2018). The labour-intensive nature of the citrus industry plays a vital role in job creation, poverty alleviation, and financial growth for the Eastern Cape province and the SRV. Financial growth for the province is essential, as racial segregation enforced by the past Apartheid regime has resulted in the Eastern Cape being one of the poorest provinces in South Africa.

In terms of land area, the Eastern Cape is the second largest province (168 966km^2) and the fourth most populous province (13%); however, it records the highest unemployment rate in the country, with 47.1% of the province unemployed (Westaway, 2012; Eastern Cape Socio-Economic Consultative Council, 2021; StatsSA, 2022). Additionally, 48.2% of females within the Eastern Cape are recorded to be unemployed (Eastern Cape Socio-Economic Consultative Council, 2021). It is thus essential that citrus cultivars within South Africa and regions like the SRV remain competitive in the international markets, as the citrus industry holds a powerful position for economic growth and employment opportunities. This requires that export regulations set by international import countries are complied with and that phytosanitary management is efficiently administered so that high-quality fruit can be traded. Phytosanitary treatments aim to eliminate, sterilise, or kill regulatory pests in exported commodities to prevent their introduction or establishment into a new area (Follett & Neven, 2006). Citrus packhouses are regarded as the centre of the postharvest operation and play a pivotal role in managing phytosanitary prerequisite standards for citrus fruits destined for export (Yaptenco & Esguerra, 2012).

2.2. IMPORTANCE OF THE PACKHOUSE AND SORTING OPERATION

With increasingly stringent export market requirements for food safety and quality, citrus packhouses are essential for implementing effective strategies to eliminate microbial, chemical and physical contamination of fruit (Bollen & Prussia, 2014; Yaptenco & Esguerra, 2012). Tasks performed in the packhouse enable fresh fruits to hold their quality for longer, thus allowing for transportation to markets worldwide (Asante & Yin, 2019). Commodities leaving the packhouse for export should not be misshapen and should be free of blemishes, diseases, pests, and mechanical damage. Additionally, packhouses are responsible for separating fruit into specific grade standards based on the fruit's quality and appearance. This enables the commodity to be sold at a specific rate based on its quality, where the most acclaimed fruit quality, grade one, is exported. In contrast, the most insignificant, grade three fruit, is sold only on the local market (Bollen & Prussia, 2014). Florkowski et al. (2014) pointed out that operations within citrus packhouses have become increasingly sophisticated and automated over the past decades because of the increased demands of the international fresh produce trade. However, it is the responsibility of the citrus sorters performing the manual inspections to ensure that, ideally, zero contaminated and pest-infested fruit pass through the system and are exported.

The sorting operation holds a critical position in the citrus packhouse as it provides a significant safeguard for sub-standard fruit to be eliminated from the packing process for export. The main task at the sorting table is to manually inspect and remove all fruit that does not conform to the required export and grade standards (Studman, 1998). Non-conforming fruits are identified by considering size, colour, shape, and blemishes. These fruits are separated and removed from the good-quality fruit to prevent cross-contamination or premature deterioration that would affect the entire crate when exported (Yaptenco & Esguerra, 2012). Therefore, citrus sorters must have a robust knowledge of the defect limits for export and non-export fruit, and this decision must be made rapidly during the sorting operation (Doyle, 1986). The sorting task is further complicated as within a season; these defect limits may change depending on the cultivars of the fruit sorted (colour variations, different pest infestation concerns) as well as market requirements (e.g., fruit sizing, appearance, market demand) (Meyers et al., 1990).

Humans have a unique ability to identify defects in fruit and determine whether they exceed the prescribed thresholds; hence most sorting operations have always been performed via human visual inspection and manual removal of non-conforming commodities (Bollen & Prussia, 2014; Nicolaï et al., 2014; Studman, 1998). However, these blemishes or pest infestation bites on the fruit vary in size, ranging from noticeable to minuscule. It is, therefore, not uncommon for a sorter to fail to identify blemished fruit if their sustained attention or visual acuity is impeded.

Citrus sorting is highly repetitive and cognitively demanding, involves long work hours performed while standing the entire shift, and often entails shiftwork. Therefore, work-related stress and fatigue, as a consequence of these work demands, could negatively influence tasks that require efficiency and accuracy, such as the citrus sorting task (Winwood et al., 2005). Furthermore, inadequate recovery from acute end-of-shift fatigue may increase the possibility of the symptoms evolving into maladaptive chronic fatigue traits (Winwood et al., 2006). Fatigue can have a severe impact not only on the health and well-being of the individual but can also induce considerable complications for organisational production (Winwood et al., 2005). These complications which affect organisational productivity as a consequence of fatigued employees include absenteeism, increased processing errors, elevated accident and safety risks, and hostile worker relationships (Murphy et al., 2014; Techera et al., 2016).

Fatigue is known to be the outcome of a diverse range of interacting factors that stem from work and non-work-related elements, which may contribute towards its pathology (Techera et al., 2016). Thus, it is essential to interrogate the theoretical literature on the fatigue phenomena, how it may manifest itself, and influences commercial enterprise and individuals' welfare.

2.3. DEFINITION OF FATIGUE

For many years, researchers have struggled to provide a comprehensive definition for fatigue because of the complex multifactorial interactions of different elements involved in its causation and the contrasting subjective perceptions experienced by the consequences of fatigue (Aaronson et al., 1999; Williamson et al., 2011; Winwood et al., 2005). Difficulties in providing a concise definition of fatigue are primarily due to the non-specific nature of its aetiology, individual differences in susceptibility, adaptations in recovery, and the need for more consensus regarding its measurements (Noy et al., 2011). Some definitions of fatigue that have been cited include; "a lower level of strength, physical capacity, or performance as a result of work activities" (Lu et al., 2017, p. 140), "a state of feeling tired, weary, or sleepy resulting from insufficient sleep, prolonged mental or physical work, or extended periods of stress and anxiety" (Caldwell et al., 2019, p. 272), or "a deterioration of mental performance due to the preceding exercise of, mental, or physical activity" (Meijman, 1997, p. 32). These definitions indicate the multifaceted nature of fatigue. Therefore, for this study, 'fatigue' was defined as a biological drive for recuperative rest in which it is recognised as having a decreased ability to perform activities at the desired level due to the combined multifactorial manifestation of lassitude, mental exhaustion, reduced physical strength, and a contribution of other social factors (Saito, 1999; Techera et al., 2016; Williamson et al., 2011).

Fatigue is a complex phenomenon that can be attributed to a diverse range of interacting factors and manifests itself in various forms depending on the nature of its cause (Saito, 1999; Williamson et al., 2011; Yazdi & Sadeghniiat-Haghighi, 2015). The consequences of fatigue do not simply dissipate with the termination of the stressor or task, as the individual requires rest and recuperation, which is necessary for the individual to return to homeostatic functioning (Craig & Cooper, 1992). The consequences of fatigue can vary depending on inter-individual perceptions and the duration of the individual's exposure to the causal factors (Lu et al., 2017; Sluiter et al., 2003). However, these effects of fatigue are best viewed as a continuum ranging from mild complaints to severe and disabling manifestations, including overstrain, exhaustion, or chronic fatigue syndrome (Dawson et al., 2011). These symptoms depend on which type of fatigue is experienced (acute or chronic) and what domain (physical, cognitive, or emotional) is affected.

2.3.1. Acute and Chronic Fatigue

The temporary state of acute fatigue is a normal, regulatory response to adverse conditions that affect an individual due to mental or physical exertion, emotional stress, insufficient recovery, or temporary illness (Fang et al., 2013; Techera et al., 2016). Aaronson et al. (1999) considered acute fatigue a protective mechanism that usually occurs within healthy individuals and has a rapid onset of consequences for a short duration. These short-term consequences are vast but are predominantly characterised by symptoms such as lack of alertness, physical discomfort, localized muscular exhaustion, reduced motor control and lowered physical performance (Lu et al., 2017; Schutte, 2006). Furthermore, acute fatigue can impact the psychological behaviour of an individual as short-term emotions such as stress, tension, anger, sadness, anxiety, or depression can be experienced (Aaronson et al., 1999; Techera et al., 2016). The quality of recovery can typically ease acute fatigue through sleep, appropriate diet, and exercise (Techera et al., 2016). However, if there is a persistent failure to recover from acute fatigue, it can be expected that maladaptive chronic fatigue symptoms will manifest (Fang et al., 2013; Winwood et al., 2006).

Chronic fatigue is perceived as excessive negative symptoms characterised by multiple contributing causes accumulated over an extended period (Aaronson et al., 1999). According to Jorgensen (2008), there is consensus within the literature that a minimum duration of 6 months of continuous exposure to acute fatigue or contributing factors must be considered chronic fatigue. Symptoms for chronic fatigue are associated with considerably more significant distress and disability than acute fatigue (Jorgensen, 2008; Techera et al., 2016). Such symptoms include irregular energy patterns for physical activity, musculoskeletal disorders, long-term depression, reduced concentration, and negative emotions about the job (Fang et al., 2013; Techera et al., 2016). Chronic fatigue has additionally been found to produce a variety of medical conditions, such as hypertension, cardiovascular disease, type two diabetes, adverse reproductive outcomes, and obesity (Dawson et al., 2011; Lerman et al., 2012; Yumang-Ross & Burns, 2014). Effects of chronic fatigue are not reversed through standard recuperative efforts for recovery, such as bed rest; higher needs for recovery (e.g., seeking medical attention) will be required (Sluiter et al., 2003).

2.3.2. Physical, Cognitive, and Emotional Fatigue

From the various definitions of fatigue, it is evident that there are different types of fatigue. Physical fatigue reduces the muscles' ability to exert force when exposed to prolonged physical exertion (Sedighi Maman et al., 2017). Physical or localised muscle fatigue can result in discomfort, diminished motor control, and reduced strength capacity (Sedighi Maman et al., 2017). However, physical fatigue may also serve as a protective function leading to the termination of the task because of depleted resources and energy that could prevent injury if the task was continued. If ignored or prolonged, physical fatigue may be severe enough that injuries or musculoskeletal disorders may transpire, leading to temporary or long-term disability (Jorgensen, 2008). Repetitive activation of a localised muscle group through dynamic or static exertion consumes more energy than a relaxed muscle group; therefore, muscles activated regularly are more susceptible to muscular fatigue (Techera et al., 2016). In occupational settings, common complaints of physical fatigue include discomfort experienced in the neck, arm, and lower extremities owing to the task-related nature of work that is repetitive and requires awkward working postures and prolonged standing (Halim et al., 2012; Saito, 1999). Therefore, monotonous, repetitive tasks require prolonged standing, and static working postures, such as those required during citrus sorting, are vulnerable to physical fatigue effects and performance decrements over extended periods (Williamson & Friswell, 2013). Furthermore, physical fatigue has been recognised to impact the performance of the physiological and psychological domain of the worker (Åhsberg, 1998).

Cognitive fatigue refers to decreases in the ability to process and respond to a stimulus cognitively, ultimately diminishing competency, productivity, and error avoidance (Boksem et al., 2005; Techera et al., 2016). Cognitive fatigue has multiple outcomes, including tiredness, loss of task motivation, and cognitive dysfunction, which sometimes overlap with symptoms of stress, negative emotions, and mind-wandering

(Matthews, Desmond, & Hitchcock, 2017). Additionally, cognitive fatigue within an occupational setting contributes to consequences that include impaired sustained attention, decreased motivation to continue with the task, difficulty processing information along with poor psychometric coordination, longer reaction times, and a sensation of weariness that affects subjective perception and visual acuity (De Vries et al., 2003; Yazdi & Sadeghniiat-Haghighi, 2015). The aetiology of cognitive fatigue in the work setting can be a combination of several influencing sources that can emerge from work-related and non-work-related factors that produce difficulty in focusing attention or responding to necessary stimuli (Techera et al., 2016).

Emotional fatigue (also cited as ‘psychosocial’ fatigue) refers to the sensation of being overextended and depleted of one’s emotional resources, contributing to the cumulative process of emotional burnout (De Vries et al., 2003). The development of emotional fatigue impacts each individual differently depending on their emotional predisposition and distress resilience (Techera et al., 2016). Negative emotions such as fear and sadness can be experienced differently by individuals because of the different emotional impulses each individual holds. A study by Ala-Mursula et al. (2005) indicated that 16 139 employees from the Finnish public sector displayed accelerated fatigue when working under stressful conditions, especially for employees previously recorded as emotionally vulnerable. When stressful work conditions are left unchanged, they will contribute towards the accumulation of fatigue and consequently affect the individual’s emotional state. In an occupational setting, shift workers have reported common psychological disturbances of anxiety and depression (Fang et al., 2013). These emotional states negatively affect the emotional capacity of the employee. Consequently, there is a reduced willingness to maintain goal-directed behaviour aimed at executing a task (De Vries et al., 2003).

2.4. CAUSAL FACTORS OF OCCUPATIONAL FATIGUE

In the work setting, fatigue is one of the most common complaints among industrial workers, as it affects every individual, regardless of skill level and experience (Dawson et al., 2011; Yazdi & Sadeghniiat-Haghighi, 2015). The Job Demands-Resource (JD-R) model assumes that every occupation has specific risk factors associated with job stress, which can be classified into *job demands* and *job resources* (Bakker & Demerouti, 2007; Bauerle et al., 2018).

Job demands refer to those physical, psychological, social, or organizational aspects of the job that require continuous physical or psychological effort (Bakker & Demerouti, 2007; Demerouti et al., 2001). This effort is associated with physiological and psychological consequences, such as fatigue (Demerouti et al., 2001). Examples of job demands include high work pressures, unfavourable physical environments, and emotionally demanding interactions with supervisors and co-workers (Bakker & Demerouti, 2007). Those demands may not always be harmful; however, they predominately accumulate into task-related stressors when they require high effort, resulting in the employee recovering efficiently from the stressors (Bakker & Demerouti, 2007). The greater the demands or stressors, the greater the negative consequence experienced by the individual (Xanthopoulou et al., 2007). Injury, errors, or fatigue can result from too many demands that coincide with insufficient resources to recover (e.g., the opportunity to sleep, rest breaks, and diet) (Bauerle et al., 2018).

Job resources refer to those physical, psychological, social, or organizational aspects of the job that either function in achieving work goals, reduce job demands, reduce negative consequences on the individual, or stimulate personal growth, learning, and development (Bakker & Demerouti, 2007; Bauerle et al., 2018). Hobfoll (2001) defines *resources* as those objects, personal characteristics, or conditions that are valued because they act as channels of protection from symptoms affecting human performance, such as fatigue. The 'conservation of resources theory' by Hobfoll (2001) states that human motivation is directed towards maintaining and accumulating resources. Job resources can be located at different levels of a working system, such as the organisational level (pay, job security, and opportunities), the interpersonal and social level (team climate, supervisor and co-worker support), the organisation of work (participation in decision making), and at the level of the individual (rest, recovery, resilience) (Bakker & Demerouti, 2007). Some individuals, however, appear to operate much more efficiently than others under conditions that induce fatigue, as individual differences and different non-work contexts influence personal resilience and recovery methods for fatigue (Matthews, Desmond, & Hitchcock, 2017).

Researchers have required help illustrating the complex relationship between the causes and consequences of fatigue, especially within occupational settings, due to the diverse origins (work and non-work influences) of its aetiology (Kant et al., 2003;

Techera et al., 2016). Gibson et al. (2003) acknowledge that there is no conclusive evidence that a single factor can be responsible for the onset of fatigue as several input factors contribute towards the development of fatigue. The multifactorial nature of fatigue complicates locating its origins, as some causal factors may exacerbate other causal factors that influence or enhance the consequences of fatigue (Techera et al., 2016). In an occupational setting, these causal factors may exist in many different forms and can influence the worker in several ways (Grandjean, 1979).

Kant et al. (2003) applied an epidemiological approach to developing a conceptual model of fatigue in occupational settings that illustrates the multifactorial causation of fatigue and the complex interactions of different risk factors that result in consequences for workers and the occupational system (Figure 1). According to this model, fatigue (light grey lines) is the result of merging factors at work (‘work situation’), outside of work (‘private situation’), and the individual characteristics of the worker, all of which collectively contribute towards the formation of negative consequences such as sick leave and disability. Many elements within the work situation can contribute towards fatigue within the workplace. These work situation elements include but are not limited to, the physical work environment, social interactions with work colleagues, conditions of employment, and the nature of the task (Kant et al., 2003). The private situation affects how employees manage their time away from work, as domestic and social life attributes may compromise their prescribed recovery periods (Kant et al., 2003). Lastly, the individual characteristics, such as health status, personality, and coping mechanisms of the employee vary vastly per individual and their responses to fatigue (Horrey et al., 2011).

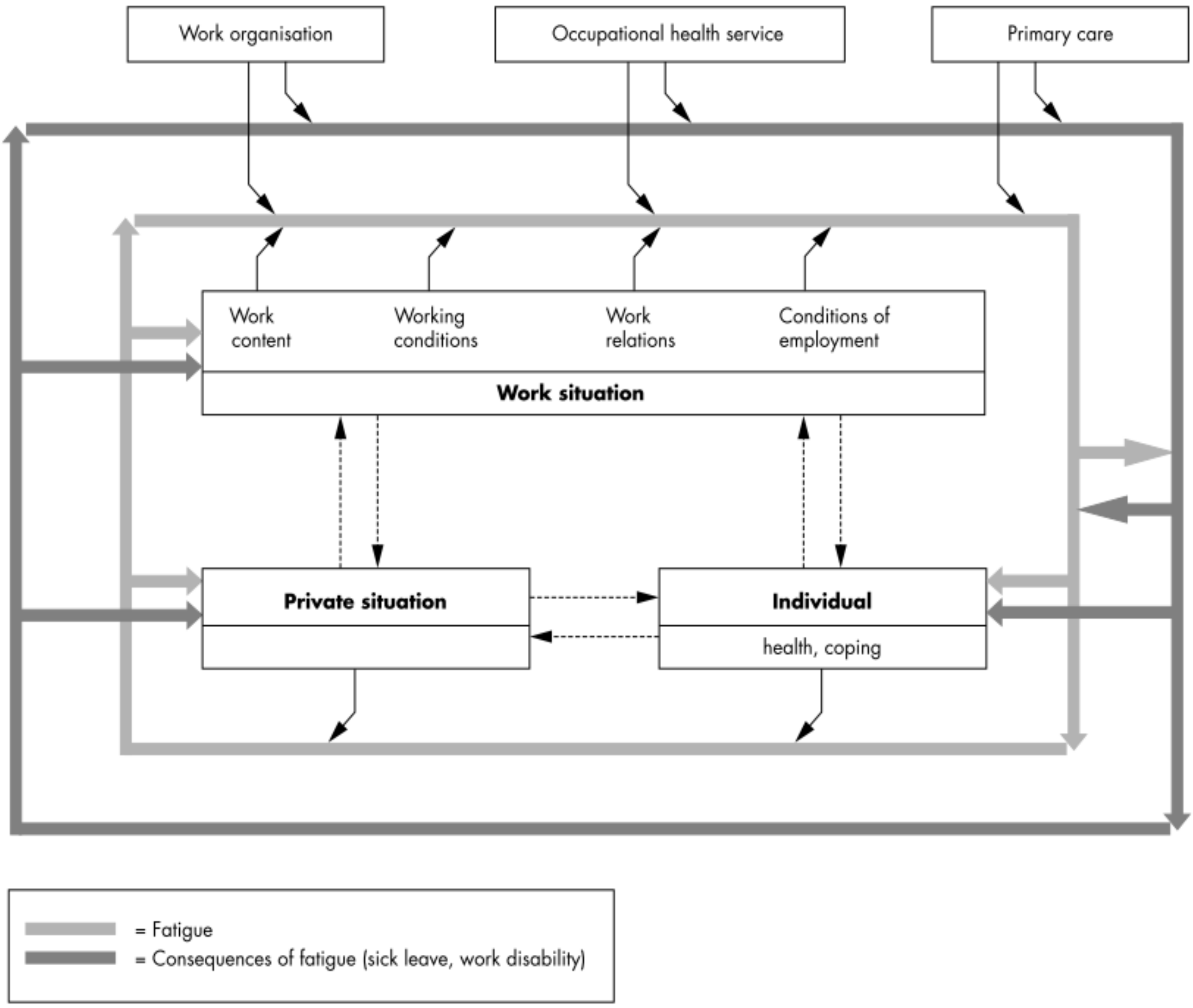

Figure 1: Conceptual model for epidemiological research on fatigue in the working population (Kant et al., 2003).

The model depicted in Figure 1 also indicated that the level of fatigue determines the intensity of the negative consequences (dark grey lines). It ultimately creates feedback loops that impact the exposure variables of the work situation, the private situation, and the individual specifically. The greater the exposure intensity of the stressor provoking the negative consequences, the higher the incidence of health effects on the individual. External elements outside the work environment contribute to fatigue's aetiology and natural course. These external elements described by Kant et al. (2003) include the work organisation, occupational health service, and primary health care, contributing to fatigue and its consequences (Kant et al., 2003). The work organisation structures the workload and sets the tempo for the employees' work intensity as the management of an organisation determines the policies, procedures, rules, and practices that employees must follow (Murphy et al., 2014; Rasmussen, 1997). These policies and practices created by the work organisation are determined by other external influences, such as international guidelines or corporate standards (e.g., in the case of this study, the citrus fruit regulations and phytosanitary management), which formulate the work structure (Rasmussen, 1997). Occupational health services are an element of public labour that promotes and protects all employees' physical, cognitive, and social well-being in all occupations. Primary health care provides consultation or professional treatment to workers who may be experiencing the consequences of severe fatigue (Kant et al., 2003). These two elements provide a positive contribution to alleviating fatigue symptoms.

This illustration by Kant et al. (2003) depicts that there is no single countermeasure to combat fatigue, owing to its multidimensional causation; thus, numerous barriers and safeguards need to be put in place to mitigate the possible accumulation of fatigue. To build a comprehensive understanding of fatigue prevalence, causal factors were identified between the three work environment elements (work situation, private situation, and individual) based on previous research and the relationship among all elements in the model. Each work system element has different causal factors and is described under the following sub-headings.

2.4.1. Work situation

Work organisation policies and practices have been known to contribute to causal factors of poor employee well-being, such as worker fatigue (Bakker & Demerouti, 2007). Examples of contributing organisational factors include worker training, work team make-up, workload, operating procedure, time pressures, and time-on-task (Satterfield & Van Dongen, 2013). Organisational elements such as work schedules, overtime work, wage payments, staffing numbers, training, and inter-shift rest periods are determined by management and contribute to employees' mental and physical well-being (Carayon & Smith, 2000).

Conditions of employment

The global rhythm of industrial work has changed to a more intense and rapid pace, including work around the clock (Folkard & Tucker, 2003). Therefore, shift systems have become an essential component of organisations, and it is the organisation's decision as to which shift system schedule would strike a balance between worker well-being and occupational productivity as they vary widely across different working systems (Folkard & Tucker, 2003; Ora et al., 2016). However, it is well-established that individuals employed on night shift schedules are more prone to fatigue and sleepiness than typical day workers as their natural sleep-wake cycle is compromised (Tucker & Folkard, 2017; Caldwell et al., 2019). This is primarily due to restricted opportunities to follow their sleep schedules as required by their circadian rhythm (Tucker & Folkard, 2017). Fatigue due to sleep loss affects how employees' effort is regulated as it decreases available cognitive resources and increases the effort required to complete the task (Williamson et al., 2011). Sleep loss makes it difficult for employees to fully engage in the task, work efficiently, and keep up with the work pace of the system. The citrus sorting task demands substantial perceptual attention; thus, adequate cognitive resources are required to ensure consistent and efficient performance (Bollen & Prussia, 2014). However, consecutively working several night shifts will result in individual adjustments to the demands placed on their circadian rhythm and allow them to adapt accordingly (Åkerstedt et al., 2014). No shift system is, however, perfect, as numerous shift system designs depend on the working situation and context. As pointed out by Tucker & Folkard (2017), there is no definition of a 'good' shift system, but rather 'better' shift systems, namely those that minimise the build-up of fatigue as they minimise sleep and circadian disruption through maximum rest intervals.

Company strategies to prevent fatigue may be achieved within the workplace through suitable work breaks, exercise breaks, or social interactions (Lerman et al., 2012). This is known as micro-recovery (Winwood et al., 2006). Rest breaks have been found to contribute positively to overall productivity as they allow workers to temporarily disengage from the workplace and recuperate from the work demands, such as through the replenishment of resources (Satterfield & Van Dongen, 2013). Management must ensure that break intervals are issued during periods that would benefit the workers and that the length of the break intervals is sufficient. When rest breaks are inadequate or inappropriately scheduled, worker burnout can be detrimental to worker well-being and productivity (Meijman, 1997).

Work conditions

Researchers have highlighted that the physical work environment imposes stressors that, over time, may negatively impact the work process and hinder employee well-being (Carayon & Smith, 2000). These environmental influences involve lighting, noise, temperature, and workplace layout (Carayon & Smith, 2000). Elements such as sufficient light intensity were found to increase the arousal of workers and often have a positive effect on cognition, especially for tasks that require sustained attention (Caldwell et al., 2019). In contrast, sleep studies have shown that low light intensities (<200 lux) increase individuals' levels of sleepiness (Åkerstedt et al., 2014). When considering noise levels, it has been acknowledged that elevated noise levels promote fatigue levels through overstimulation (Techera et al., 2016). This overstimulation produces negative cognitive consequences such as attention disruptions, disengagement, and vigilance stressors (Carayon et al., 2006; Warm et al., 2008). Similarly, exposure to extreme temperatures leads to thermal stress and can alter neural function, reduce blood flow to muscles, and cause discomfort (Mahdavi et al., 2020). These effects of temperatures are accredited to discomfort and physical and cognitive fatigue (Mahdavi et al., 2020). Lastly, poor workspace design has been shown to influence awkward work postures and movements that contribute to physical fatigue and can lead to diminished task performance (Carayon & Smith, 2000). When workplaces are poorly designed or misaligned with the worker's capabilities, physical fatigue can contribute towards musculoskeletal disorders (Yung et al., 2014). Thus, workplaces need to be adequately designed to provide comfort and flexibility for the worker, as it can induce positive physical and psychosocial effects, improving organisational output (Murphy et al., 2014).

Work relations

The social environment is the network of social relationships within the work system that facilitate social support for employees through management and co-worker interactions influencing work behaviours (National Research Council and Institute of Medicine, 2013). Carayon et al. (1999) defined psychosocial work factors as the perceived subjective aspects of the work organisation that have an emotional connotation for other workers, supervisors, and managers. Social support can alleviate perceptions of fatigue, while conflict may produce negative emotional fatigue. Daily harassment, or workplace abuse, from other co-workers or supervisors for prolonged periods can cause severe mental fatigue and psychological instability (Techera et al., 2016). Different workgroups, with different supervisors or shift schedules, can experience different levels of strain even when working within the same work system and performing similar tasks (Murphy et al., 2014). Additional psychosocial work factors such as perceived workload, lack of job control, lack of job promotion, and doubt of one's job future can prompt short-term influences on cognitive fatigue that may disturb an individual's cognitive processing (Carayon & Smith, 2000).

Work content

Occupational tasks warrant specific job demands of the worker and require different types of work (cognitive and physical) (De Vries et al., 2003; Verdonk et al., 2010). Numerous task-related attributes have been linked to fatigue and contribute towards performance decrements (Williamson et al., 2011). Job demands contribute towards different stressors on the worker, which are generated from the type of work, time-on-task, and workload.

Cognitive work is a critical component of most modern industrial work activities that involve workers maintaining sustained attention or vigilance, mainly on production lines (Warm et al., 2008). Vigilance is the ability of the individual to maintain a fixed focus of attention on a stimulus or work task over a prolonged period (Head & Helton, 2014). Psychological repetitiveness or extended periods of cognitive processing (e.g., prolonged vigilance, lack of challenge, or unstimulating work) have been documented to promote mental fatigue, which in turn threatens organisational effectiveness and worker well-being (Pascale Carayon & Smith, 2000; Mehta & Parasuraman, 2014). There have been apparent performance impairments for cognitive tasks requiring sustained attention or vigilance, particularly in monotonous tasks, with citrus sorting as one example (Horrey et al., 2011). An individual's ability to remain vigilant for effective performance depends on several factors, such as the number of mental resources available within their capacity and their resilience to cognitive stressors (Head & Helton, 2014).

Furthermore, when a task requires physical repetitiveness, sequential movements of the body segments become modified as the muscular forces and movement coordination are altered due to muscle activation being affected by physical fatigue (Sedighi Maman et al., 2017). Generally, repetitive work requires a rapid pace and frequent movements or physical exertions of the same body part (Kilbom et al., 1996). Thus, regular exposure to physically demanding job demands where the frequency of exertion is high or the worker does not receive a sufficient recovery can result in persistent fatigue or discomfort (Kilbom et al., 1996; Yung et al., 2014). Exposure to prolonged physical fatigue induced by the task can lead to discomfort, pain, and potentially musculoskeletal disorders if ignored for a substantial period (Mahdavi et al., 2020). However, gradual exposure to increased physical exertion has a training effect on the musculoskeletal system and allows for adaptation to the work demands (Kilbom et al., 1996).

Time on task is often referred to as time spent on a task or the work shift (Williamson et al., 2011). When high job demands are imposed over prolonged time-on-task periods, harmful fatigue outcomes can evolve, such as emotional exhaustion, lapses in concentration, job-related depression, and severe physical disability (Demerouti et al., 2001). As time-on-task progresses, mental and physical resources are depleted more rapidly than can be replenished, which commonly induces performance impairments (Head & Helton, 2014). Time-on-task could influence occupational fatigue if not managed correctly, as it can be potentially compounded by the time of day in which the task is executed, the worker's waking time, and the time since the last rest break (Williamson et al., 2011). Rest breaks help alleviate the stressors produced on individuals through prolonged time on task when engaged with physically or cognitively intensive tasks (Satterfield & Van Dongen, 2013).

The workload is another task-related factor known to contribute to fatigue and has two components: the quantity of work and the complexity of the work to be performed (Maslach & Leiter, 2008). High work quantity (referred to as 'workload') is defined as the product of task demands and time (Techera et al., 2016). It is known that intensified cognitive and physical work demands that exceed an individual's capabilities may result in burnout (Maslach & Leiter, 2008). A systematic review by Kolus et al. (2018) concluded that there was ample evidence of an association between increased workload and reductions in work accuracy. Furthermore, it has been found that heavy workloads can negatively impact sleep quality, which can induce high levels of perceived sleepiness (Techera et al., 2016)

It was once thought that the adverse effects of fatigue occurred only during complex physical and cognitive tasks over a prolonged period (Williamson et al., 2011). However, it is now acknowledged that simple or monotonous tasks over a sustained period can also have performance decrements due to worker fatigue or increased sleepiness (Williamson et al., 2011). Much research indicates that monotonous work tasks cause significant boredom in the workplace, negatively impacting cognitive processes and reducing alertness (Loukidou et al., 2009). Additionally, Williamson et al. (2011) clarified that instead of monotonous tasks causing fatigue, symptoms of sleepiness might manifest because of the low-stimulus simulations of monotonous tasks. Thus, monotonous tasks, such as citrus sorting, could induce symptoms of sleepiness.

2.4.2. Individual characteristics

Individual characteristics play a significant role in the development and sensation of fatigue as the fatigue threshold, defined as an individual’s ability to tolerate or resist fatigue, varies between individuals (Dawson et al., 2011). The individual component is influenced by the ‘health’ of the employee and the ‘coping’ mechanisms used by the employees. However, it should be recognised that numerous other individual factors also influence the onset of fatigue resilience (Carayon & Smith, 2000). Inter-individual differences in health status and demographics influence an individual’s resilience to combat the nature of the stress response and the accumulation of fatigue (Carayon & Smith, 2000). Additionally, individuals can cope with fatigue responses differently, which determines how rapidly they can recover from fatigue symptoms.

Several demographic factors of an individual, such as gender, age, educational level, personality, cultural obligations, and socio-economic status, can differentially contribute to fatigue and its negative consequences, especially when coupled with the context the individual resides within (Horrey et al., 2011). Fatigue responses, particularly endurance in physical task activities, have shown to be higher in individuals with older age (Mahdavi et al., 2020); however, this finding is contradictory as some studies report no differences in fatigue levels between different ages (Winwood et al., 2006). A gender-based study by Engberg et al. (2017) on the general population confirmed that women living in a lower socio-economic level were reported to be more fatigued. Although this study was conducted in a Swedish context, it can be speculated that women and those living in poverty are potentially at a higher risk of fatigue. These findings concur with those of Sluiter et al. (2003), who state that individuals of low socio-economic status, as defined by personal income, occupation, and education level, are considered to suffer worse health effects than people from a higher socio-economic group. Furthermore, an individual's personality traits influence how fatigue is perceived as resilience to anxiety and fluctuation in mood changes is different across individuals (Samaha et al., 2007).

Furthermore, the overall health status of an individual can influence an individual's fatigue profile; for example, individuals with underlying comorbidities have accumulated pressures to recover from their disturbed homeostatic state to function effectively (Finsterer & Mahjoub, 2014). Comorbidities that affect an individual's health status may include underlying chronic illnesses, depression, effects of continuous consumption of alcohol or drugs, or pre-existing acute illnesses (Finsterer & Mahjoub, 2014). While a healthy individual may experience minor symptoms of fatigue, the same individual may perceive more severe fatigue symptoms during acute or chronic illness (Finsterer & Mahjoub, 2014). The fatigue prevalence rate in the Dutch population was 36.4% higher, predominantly in individuals associated with unhealthy living conditions and chronic illnesses (Kocalevent et al., 2011).

When faced with fatigue, individuals rely on different coping mechanisms to manage its negative consequences. Individuals are primarily responsible for protecting themselves from fatigue consequences by acquiring the necessary coping mechanisms and recovery methods. The most common self-administered coping mechanism for fatigue is the consumption of caffeine, which is present in many foods and drink items such as coffee, tea, energy drinks, supplements, or chocolates as it acts as a stimulant (Satterfield & Van Dongen, 2013; Schutte, 2006). However, caffeine is a short-term solution to alleviating symptoms of sleepiness and fatigue (Geiger Brown et al., 2014). When considering recovery, Techera et al. (2016) describe recovery from fatigue as reversing the adverse effects of mental and muscular exertion to the return of the pre-fatigued state through rest, but predominantly through sleep. The primary method for recovery from work-related fatigue occurs during non-work periods, known as inter-shift recovery (Winwood et al., 2005), but can also encompass more extended non-work periods such as weekends or vacations. If recovery is not achieved because of accumulated sleep loss, the sleep deprivation process can be converted to chronic fatigue, resulting in long-term severe mental and physical health problems (Techera et al., 2016).

Sleep loss or sleep deprivation is arguably the most common and the most significant factor contributing towards the development of fatigue (Dawson et al., 2011; Techera et al., 2016). Most individuals require between 7-8 hours of sleep per night to function optimally the following day; however, sleep requirements differ between persons due to inter-individual characteristics (Lerman et al., 2012). Factors influencing sleep behaviour include genetic makeup, attitudes towards sleep, knowledge of sleep benefits, health, disease, and living conditions (Caldwell et al., 2019). However, these factors that influence sleep behaviour are embedded in the societal context in which the individual is positioned, such as their socio-economic status, sleep environment, occupation, family demands, and home circumstances (Caldwell et al., 2019). The effects of partial sleep loss (2-3 hours of sleep loss a night) can last several days and can generate a noticeable reduction in performance that may harm the well-being of the individual (Dawson et al., 2011; Techera et al., 2016; Williamson et al., 2011). Sleep debt can originate from a reduced quality and quantity of sustained sleep or an extended time awake, as it produces a homeostatic drive to sleep (Williamson et al., 2011). Sleep loss studies conducted via imaging and functional performance tests demonstrate that the prefrontal cortex region in the brain is severely affected by sleep loss (Caldwell et al., 2019; Dawson et al., 2011).

Although demographic traits, health status, coping mechanisms, and recovery methods influence the fatigue profile at the level of the individual, the private situation may influence the fatigue profile with additional stresses. The association between the private situation plays on the work situation, and the individual can be seen with the arrows representing a feedback loop (Figure 1).

2.4.3. Private situation

An individual’s personal life outside of the work environment, such as their social life at home (e.g. caregiving duties, presence of a new-born, hobbies, social support, exercise) and commuting times to and from work, may negatively affect the worker’s recovery from fatigue (Satterfield & Van Dongen, 2013). Furthermore, some activities (i.e. substance abuse or social interactions) can contribute towards the inadequate use of the provided recovery periods following work shifts (Techera et al., 2016). When a home or social demands interfere with the devoted inter-shift recovery period, fatigue can accumulate and filter through to work again, hindering the performance of the individual when returning to work (Winwood et al., 2006). Additionally, social demands vary significantly between workers as diversity exists within family obligations, social activities, commuting times to work, and the absence or presence of sleep opportunities during non-work hours (Dawson et al., 2011). Furthermore, the recovery period is interfered with when workers (especially women) have dependents at home that require domestic responsibilities and care duties. These dependents can be infants, adolescents, or elderly relatives. Winwood et al. (2006) found that workers with a spouse or partner have an advantage in recovering from stress or fatigue because of the positive value of companionship that allows for sharing domestic duties, tensions, and concerns. Understanding the development of occupational fatigue arguably demands a holistic understanding of the non-work activities, the work-related factors, and the individual's recovery process from the efforts of the last shift (Winwood et al., 2005). Repeated failure to recover from fatigue can induce negative consequences to individual well-being and can further transpire into chronic fatigue symptoms (Kajtna et al., 2011).

2.5. MEASUREMENT OF FATIGUE

Although several tools exist to assess and quantify fatigue, it is difficult to determine which instrument is appropriate to evaluate this construct as it depends on the research aims and objectives (Dittner et al., 2004). Fatigue measurement scales can be measured subjectively or objectively, where the scales can assess one construct of fatigue (unidimensional) or several constructs (multidimensional) (Saito, 1999; Shahid et al., 2010).

Measures of objective fatigue on the individual focus primarily on the physiological processes (e.g., electromyography, blood chemical investigation, structural magnetic resonance imaging) or on occupational performance (e.g., the number of errors, reaction time, or injuries) (De Vries et al., 2003; Finsterer & Mahjoub, 2014). These measures are not dependent on the workers' opinions, impressions, or feelings; however, they often require equipment that may be costly due to the equipment needed or interfere with the employees' working abilities (Rahimian Aghdam et al., 2019). Additionally, many signs and symptoms of fatigue are essentially a subjective experience, which influences the objective measures; thus, fatigue assessments are predominantly measured subjectively (Dittner et al., 2004). Subjective measurements of fatigue rely on people's perceptions and include tools and methods such as sleep diaries, rating scales, interviews, or questionnaires (De Vries et al., 2003). The subjectivity of the symptoms experienced reinforces the importance of a self-reported measure that captures the respondent's point of view rather than the assessor's assumptions (Mota & Pimenta, 2006). With most subjective measurements being self-report scales, the information obtained from the scale depends on the definition of fatigue based on the assessor's interpretation and what questions are asked, which in turn are based on the research question to be answered (Dittner et al., 2004). Compared to objective measures of performance, self-reported measures have several practical advantages in field research due to their widespread availability; they are easy to distribute, inexpensive, and simple to complete for participants and researchers (Christodoulou, 2017; Salters-Pedneault, 2020). The different scales can measure fatigue severity, phenomenology, the impact of fatigue, or an overall perspective; thus, the choice of scale depends on what aspect of fatigue is desired to be assessed (Dittner et al., 2004; Mota & Pimenta, 2006).

Unidimensional scales are designed to obtain a score that captures heterogeneous signs, symptoms, and behaviours caused by fatigue (Dittner et al., 2004). When unidimensional measures are well-designed and can show good levels of internal consistency and test-retest reliability, they can provide meaningful information on a specific aspect of the construct of fatigue using a reductionist perspective (Dittner et al., 2004). However, suppose an instrument assesses physical fatigue in isolation; it only assesses a single component of the phenomenon, where possible increases in mistakes of judgment about the severity of the impact can be assumed (Mota & Pimenta, 2006). On the other hand, multidimensional assessments are generally lengthier and provide a more detailed assessment of fatigue using a holistic approach through evaluating qualitative and quantitative data (Dittner et al., 2004). Such detailed assessments allow a valuable comparison of fatigue experiences under different conditions for descriptive research. They can provide insights into the mechanisms that underlie specific aspects of fatigue causation (Dittner et al., 2004).

2.5.1. Fatigue Measurement Scales

The subjective nature of fatigue, the different individual responses to its consequences, and the unknown aetiology of fatigue provide difficulty in measuring this phenomenon (Åhsberg, 1998; Shen et al., 2006). There is no 'gold-standard' measuring tool for fatigue; however, several tools seek to evaluate the phenomenon's unique aspects (Rahimian Aghdam et al., 2019). A self-report instrument is arguably the most helpful method to determine the subjective nature of fatigue in fieldwork research as it is less costly, readily available, and less intrusive to the working procedure (Kos et al., 2005). Various forms of subjective unidimensional assessments of fatigue have been used in research.

The Fatigue Assessment Scale (FAS) is a 10-item unidimensional questionnaire that evaluates the intensity of symptoms for patients experiencing chronic fatigue (Michielsen et al., 2004; Shahid et al., 2010). It has also been defined as the 'Patient Reported Outcome Measure' as the scale is predominantly used on patients with sarcoidosis (Hendrick, 1996). It was developed on large samples of the Dutch working and general population where the items were extracted from existing fatigue assessments that analysed how the subject generally feels (De Vries et al., 2003). The assessment targets 'general fatigue' and does not measure emotional stability or depression. The scale applies a 5-point Likert scale; overall scores can range from 10 (lowest level of fatigue) to 50 (highest level of fatigue).

According to Dittner et al. (2004), the Fatigue Severity Scale (FSS) is one of the best-known and most-used unidimensional fatigue scales. The purpose of the FSS is to measure the severity of fatigue in a manner that explores the perception of fatigue in several different medical disorders and facilitates research purposes (Neuberger, 2003). The FSS is a self-administered questionnaire that contains nine statements and is equipped with a 7-item Likert scale. Subjects must circle the value on how appropriately the statements applied to them in the preceding week. A low value indicates that the statement is irrelevant, while high values indicate agreement with the statement. A study by Valko et al. (2008) acknowledged the FSS as a valuable tool to quantify fatigue, as it was able to differentiate between patients with different diseases and healthy individuals. One disadvantage of this scale is that the questions assume that the subject already perceives fatigue; for example, question 6 states, "My fatigue prevents sustained physical functioning". Therefore, when exploring a population sample that is unexplored in previous research, the researcher is not in the position to assume fatigue is present.

However, fatigue is a multifactorial phenomenon; thus, unidimensional fatigue assessments fail to capture the whole sphere of fatigue symptoms and are limited to research on fatigue prevalence (Shen et al., 2006; Stein et al., 2004). Therefore, an overall assessment of fatigue needs to take a multidimensional approach in its investigation as different facets of its symptoms need to be acknowledged to understand its whole extent (Téllez et al., 2005). Different multidimensional subjective fatigue measurement scales include the Fatigue Questionnaire and the Modified Fatigue Impact Scale.

The Fatigue Questionnaire (FQ) is a multidimensional survey that consists of 11 items measuring fatigue-related consequences, which target the physical (7 items) and mental (4 items) domains of the individual (Dittner et al., 2004). It was initially developed as a hospital study for patients with chronic fatigue syndrome. It exhibits good validity in the clinical setting but has also been used in a general population study in Norway (Loge et al., 1998). The questionnaire queries fatigue symptoms that subjects have experienced within the past month and how they perceived the consequences to have affected them (Loge et al., 1998). Higher FQ scores were seen in individuals that were living with disabilities and those that reported diseases or current health issues (Dittner et al., 2004). The popularity of the FQ lies in the speed at which it can be completed and the simple structure of its design.

The Swedish Occupational Fatigue Inventory (SOFI) was developed for practices in occupational settings that assess high physical and mental work (Åhsberg et al., 2000). It was developed to evaluate fatigue by investigating the subjective qualities of fatigue in workers of different occupations (Johansson et al., 2008). The instrument consists of 25 statements that fall under the different dimensions: *lack of energy, physical exertion, physical discomfort, lack of motivation, and sleepiness* (Åhsberg et al., 1998; Åhsberg et al., 2000). Each statement is scored on a 7-point Likert scale (0= not at all; 7= to a very high degree) to the question "To what extent do the expressions below describe how you feel now, or after work?" (Åhsberg et al., 2000, p. 459). However, these statements are singular phrases rather than questions, which may be confusing or misinterpreted by employees who do not have a high level of education or if statements are not correctly translated.

The Modified Fatigue Impact Scale (MFIS) is a modified version of the Fatigue Impact Scale (FIS) which was developed for clinical purposes, assessing the overall quality of life in individuals with Multiple Sclerosis (Larson, 2013). The 40-item FIS was abbreviated to the 21-item MFIS by eliminating items considered content-redundant (Larson, 2013). The MFIS is a multidimensional scale that is longitudinal in its application as it reports on the physical (9 items), cognitive (10 items), and psychosocial (2 items) functioning of the individual over an extended period (Kos et al., 2005; Learmonth et al., 2013; Téllez et al., 2005). The threshold score of 38 (out of a maximum score of 84) was based on the study of Flachenecker et al. (2002), which correlated the MFIS with the Fatigue Severity Scale and its established 'fatigue' and 'non-fatigued' scores. The National Multiple Sclerosis Society has proposed the MFIS as a good measuring tool with proven validity and reliability in assessing fatigue's impact on daily activities (Téllez et al., 2005). The MFIS is also considered to accurately assess patients with multiple sclerosis in physical, cognitive, and psychosocial domains (Téllez et al., 2005). Furthermore, a study by Kos et al. (2005) aimed to determine the reproducibility and validity of the MFIS in four European countries. This was the first cross-cultural study of MFIS, and it found no significant difference in the psychometric properties between the four countries, indicating that MFIS is a powerful tool.

2.5.2. Sleepiness Scales

Although sleepiness and fatigue are two different entities, many people use the terms interchangeably as they are unaware of how to separate the feelings of being sleepy, tired, or fatigued (Shahid et al., 2010). Similar to fatigue, sleepiness is multifaceted in its development; thus, both phenomena can be influenced concurrently as the lack of sleep contributes towards individual fatigue, while increased fatigue levels promote sleepiness (Williamson et al., 2011; Yumang-Ross & Burns, 2014). It is thus necessary to acknowledge both phenomena, as it will be challenging to determine if the primary concern is fatigue or sleepiness.

Sleepiness is defined as the drive to fall asleep, where the gold standard methods to assess sleepiness are multiple sleep latency tests (Åkerstedt et al., 2014). However, these tests, as well as performance measures or electrophysiological variables that indicate sleepiness are challenging to implement in real-life contexts as they require expensive equipment and training and are intrusive to the individual and the work process (Åkerstedt et al., 2014). Therefore, repeated subjective reports of sleepiness are a more pragmatic way of gathering information about sleepiness in field research as they are quick, cost-effective, and do not interfere with the work process (Åkerstedt et al., 2014; Gillberg et al., 1994; Kaida et al., 2006; Miley et al., 2016). Various sleepiness scales exist and have been used in research studies.

The Epworth Sleepiness Scale (ESS) is a self-administered subjective measurement of a patient's perceived sleepiness over a day, and that has been widely used in the field of medicine (Johns, 1991). The scale provides subjects with eight different 'scenarios', and subjects are required to rate the probability of them becoming sleepy in each (0 being 'no chance of dozing off', and 3 being 'high chance of dozing'). The final score predicts whether a subject is experiencing excessive sleepiness and requires possible medical attention (Johns, 1991). The ESS acknowledges that individuals have different lifestyle factors and living routines; for example, the scale does not ask how frequently a subject dozes off while watching television. Instead, it asks how 'likely' they are to doze off if watching television (Johns, 1991). However, some of these scenarios may not apply to participants from lower socio-economic backgrounds. For example, some subjects may not own a television or even a car, and therefore they would be unable to respond to a statement if it is irrelevant to them.

The Stanford Sleepiness Scale (SSS) is a self-administered sleepiness assessment in research and clinical settings (Shahid et al., 2012). The scale evaluates a subject's perceived sleepiness at a specific moment, making it suitable for repeated use over time (Shahid et al., 2010). The scale requires subjects to select one of seven statements that best represent their level of sleepiness at that moment. While the scale has gained good validity compared with other assessments, it has been acknowledged to have a poor correlation with objective measures in some circumstances (Maclean et al., 1992).

Finally, the Karolinska Sleepiness Scale (KSS) was developed as a unidimensional scale that explored subjective sleepiness and was validated with other objective measures (Åkerstedt & Gillberg, 1990). The KSS is a widely used tool in studies of shiftwork, sleep deprivation, and driving, where its purpose is to assess the subjective sleepiness of the individual at a specific time of day (Kaida et al., 2006; Miley et al., 2016). The KSS requires the subject to integrate and translate the sensation they currently experience to statements anchored by a number from 1-9 (Gillberg et al., 1994). It is a simple, quick, and cost-effective method to assess subjective sleepiness in the field and subjects with limited education can easily understand it.

CHAPTER 3: METHODOLOGY

3.1. RESEARCH CONCEPT

This study aimed to monitor the prevalence of fatigue amongst the sorting staff in citrus packhouses within the Sundays River Valley throughout one harvesting season and to interrogate potential factors that could contribute to its development. It was assumed that worker fatigue would increase throughout a citrus harvesting season, which could influence their well-being and sorting performance. Furthermore, the multifaceted nature of fatigue and the influence of dynamic contributing factors must be acknowledged.

The research approach was to investigate fatigue prevalence and possible causal factors by obtaining multiple measurements at intervals throughout a harvesting season. This would provide a more realistic representation of the sample's perceptions of fatigue rather than a single "snap-shot". Quantifying fatigue levels, its progression throughout a harvesting season, the dominant type of fatigue affecting the workers, and whether shiftwork or specific work-related factors contribute to its development could provide vital evidence to inform a suitable fatigue risk-management system. In addition, such information would contribute towards future research studies within the citrus industry, as little is known about the human factor within the citrus industry.

To accomplish this, fatigue must be understood holistically as it is multifactorial in its causation and diverse in its manifestation. However, the task of understanding the nature of fatigue entirely would be too immense; thus, a scope boundary should be acknowledged. The researchers focused primarily on elements within the work system in which the participants reside. Elements that were assessed in the work system consisted of organisational, environmental, task, tool, and individual components. Furthermore, non-work-related elements and demographic information were also recognised to acknowledge their context but were not the primary focus of the study (Wilson, 2000). Likely, some influencing components that may play a role in the onset of possible worker fatigue have not been measured. For example, cultural background, religion, personality, mood, or diet could influence the participant's perception or recovery of fatigue symptoms.

3.2. RESEARCH DESIGN

This study followed a cohort research design, as the participants all shared the same characteristics regarding working positions and work demands at the citrus packhouse. This study used a mixed-methods approach to assess the type and level of fatigue throughout a harvesting season and determine the contributing factors as it captured both qualitative and quantitative data. Tashakkori & Creswell (2007, p. 4) define a mixed-methods approach as “research in which an investigator collects, analyses data, integrates the findings and draws inferences using both qualitative and quantitative approaches or methods in a single study”. The two parts of the study were conducted on both day and night shift workers, where the research design is depicted in Figure 2.

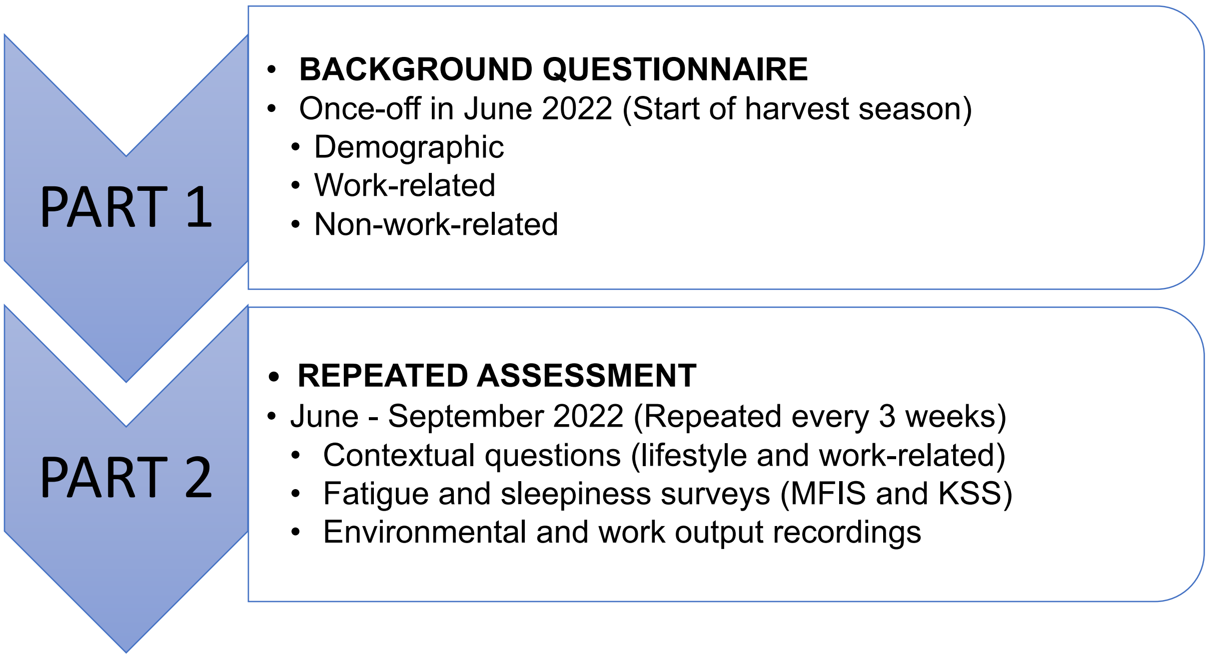

Figure 2: Visual depiction of research design and process of research design.

3.2.1. Part 1

A background questionnaire that was administered once off contained questions regarding the participants’ demographics, as well as work-related and non-work-related questions. The nature of this questionnaire was explorative as there was no previous knowledge of the working population available in previous research. This questionnaire aimed to obtain insights into the sample investigated and individual factors that may contribute to potential fatigue development. This questionnaire was distributed at the beginning of the harvest season to workers who consented to participate in the study.

3.2.2. Part 2

The second part of this study, which took a repeated-measures approach, investigated the prevalence of fatigue and contributing factors. Exposure variables that cause fatigue may follow different courses of effect at different points of a season, mainly when task demands vary according to work pressures (Kant et al., 2003). This repeated assessment was structured as a cross-sectional design as data were collected repeatedly at selected points throughout the citrus harvest season. Variations in responses can only be established when more than one instance is examined (Bryman, 2012). Thus, the repeated assessment was administered in three-week intervals for a complete citrus harvesting season, beginning in April 2022, and ending in September 2022. The motive for the three-week cycle was to gather as many data points throughout the season as possible while keeping in mind the access period granted to the researcher by the packhouse management so that the work processes were interrupted as little as possible. Another consideration was that the assessments should take place on different days of the week so that intra-week variations in workload would be assessed. For example, week one testing would be conducted on a Monday, and week two testing would be conducted on a Tuesday (see Appendix A.1 for the research schedule). The structure of the repeated assessment began with contextual questions about the participant's lifestyle and work-related factors, which was followed by the fatigue and sleepiness surveys. The repeated assessment was completed by the participants towards the end of the shift to recognise their perceived fatigue levels after a considerable number of hours on the task. Additionally, the researcher measured the environmental and work output recordings towards the end of the shift.

3.3. PARTICIPANT CHARACTERISTICS

Participants recruited for this study had to be employed in the citrus packhouse under investigation as a 'sorter'. Participants could not participate in the study if they were promoted or acquired a new job. Additionally, participants were excluded if they did not complete the season as a 'sorter' due to retirement, promotion, resignation, or their employment contract being terminated.

The recruitment strategy for the study involved assistance from the packhouse management and sorters' supervisors. Supervisors facilitated 'freeing up' employees of the day and night shifts from the sorting line to allow the researcher to inform employees about the study and to enquire if they would consent to participate.

3.4. MATERIALS AND TOOLS

Assessing fatigue is complicated due to its subjective and multidimensional characteristics. It is, therefore, usually evaluated through self-report instruments as they provide unique assessments of the individual's experience and current feelings of fatigue (Kos et al., 2005; Christodoulou, 2012). Many self-report instruments aim to collect subjective information in an approach that may allow for quantitative analysis and interpretation of the results (Larson, 2013). The instrument of choice must have adequate psychometric properties of validity and reliability to achieve this. Furthermore, the language in questionnaires must be accessible to participants (Bryman, 2012). Therefore, all assessments and surveys used in this study were translated into Afrikaans and isiXhosa for participants to understand the questions fully. Answering all questions was voluntary and kept confidential to protect the participants' responses.

3.4.1. Background questionnaire

Part 1 of the study comprised a background questionnaire (Appendix A.2) that was self-developed as no previous study exists using a sample group in this context that could have been used. Close-ended questions were used as most answers did not require an extensive reply, thus allowing for categorical responses to be generated for inferential statistical data analyses. The first section of the questionnaire focused on personal information that aimed to gain insights into the demographics and backgrounds of the participants. These include age, sex, home language, race, marital status, and the highest level of education. Age and sex were asked to understand the biological attributes of the participants, whereby marital status and level of education are potential influences that could affect fatigue (Fang et al., 2013). Race and home language information would provide a better understanding of the language influence to use during testing necessary for translation and possible cultural factors influencing the participants. Participants were also asked how many dependents (children and elderly) lived within their household. This could indicate how many individuals require parental care when the participants return from work and the financial pressures that participants had to support others. Questions about chronic illnesses and perceived general health were also asked, as these factors are known to impact the severity of fatigue in individuals and further influence their work performance (Finsterer & Mahjoub, 2014). An "I prefer not to answer" option was provided to allow participants an option not to reveal sensitive personal information if they were not comfortable doing so. Lastly, research participants were asked whether they regularly smoked, drank (alcohol), or used other substances, as these factors have been acknowledged to influence fatigue's effects or the recovery period. For example, the nicotine from smoking is known to cause individuals to struggle to fall asleep or stay asleep compared to non-smoking counterparts, which will affect the recovery period of an individual suffering from fatigue effects (Caldwell et al., 2019).

The second section of this questionnaire enquired about the participants' working contexts and the organisation's work structure. Questions were limited to how many years they had worked in the current packhouse they were employed in, how many years they had worked as a citrus sorter, whether they had received any previous training within the current year, if they had a second paid job, and what transport they used to get to work. These questions aimed to understand their work experience and potential additional demands that could contribute to fatigue's multifactorial influence. The questionnaire was translated into English, Afrikaans, and isiXhosa so the participants could easily understand it.

3.4.2. Repeated Assessment

Part 2 of the study also comprised two sections, the first of which was the repeated assessment (Appendix A.3) which consisted of a combination of contextual questions, the Modified Fatigue Impact Scale, and the Karolinska Sleepiness Scale.

Contextual Question

The data collection process started with contextual questions three weeks throughout the harvesting season. The questions in this section were also self-developed, as no previous assessments had been conducted on a similar sample in this context. These contextual questions aimed to gather information about the factors that would vary daily or over weeks and could have influenced fatigue development on assessment days. Since external elements outside the work environment also contribute to an individual's fatigue aetiology, it was considered necessary to acknowledge participants' lifestyle components that may have played a role in the fatigue profiles. Open-ended questions included waking time, hours of sleep, and whether participants consumed caffeine before or during their shifts. Additional factors such as sleep and caffeine are known to have short-term effects on perceptions of fatigue (Geiger Brown et al., 2014) and were therefore asked every day of the data collection.

Furthermore, a 5-point Likert scale, ranging from 1 (not manageable) to 5 (very manageable), was used to obtain insights into the participants' perceived work-pace (i.e., how rapidly the fruit was moving along the conveyor belts). A second 5-point Likert scale, which was extracted from the Standardized Shiftwork Index by Costa et al. (1995), was used to recognise to what extent working day or night shift interfered with participants' lifestyle elements such as (a) Sleep, (b) Social life, (c) Domestic life, and (d) Work performance. This scale ranged from 1 (never) to 5 (always). It was acknowledged that when answering these two scales, there was an inverted direction of responses (for work-pace perception: 1= not manageable, whereas for the standardized shiftwork: 1= shiftwork never interferes), which may have created confusion for participants. However, the two scales were not modified as this would have altered the integrity and outcome of the scales.

Modified Fatigue Impact Scale

Following the contextual questions was the Modified Fatigue Impact Scale (MFIS), which aimed at quantifying the fatigue level and the type of fatigue. It needs to be acknowledged that this scale was initially developed to assess the impact of fatigue on the quality of life among patients with MS and has been used as an outcome measure in several clinical trials (Larson, 2013). This scale has yet to be used within a workplace setting or an environment outside of the clinical setting. The motive for utilising this tool instead of other existing workplace fatigue scales is due to the underlying structure, simplicity, subscale algorithms, and the multidimensional nature of the investigation. The structure of the MFIS is short, allowing for a quick response time and providing a Likert scale for simple responses. The questions are short and simple, thus easy to comprehend for users with limited education or where potential language barriers exist. Additionally, Larson (2013) suggests that the MFIS can be used as a comprehensive (total score) and multidimensional (separate subscales) assessment of the impact of fatigue among individuals. Multidimensional assessment is necessary when researching fatigue prevalence amongst a working population that has been unexplored and which aspect of fatigue may impact them. A unidimensional assessment scale would not have been appropriate for this study as a holistic understanding of the different dimensions contributing to the overall fatigue experience is required.

The MFIS required participants to answer 21 questions by circling a number from 0-4 (0= “Never”, 1= “Rarely”, 2= “Sometimes”, 3= “Often”, 4= “Always”), which best describes how fatigue had, or had not, affected them in the past week. This assessment was administered at the end of the shift to explore the levels of fatigue experienced following a working shift. In acknowledging the multifactorial nature of fatigue, the MFIS contains nine items referring to ‘physical’ fatigue, ten ‘cognitive’ items, and two ‘psychosocial’ items. The higher the combined total score, the more severe the impact of fatigue on the quality of life (Larson, 2013). The total score of the MFIS ranges from 0 to 84, with the ranges of scores for each subscale as follows: physical, 0 to 36; cognitive, 0 to 40; and psychosocial, 0 to 8. No data have so far been published regarding population norms for the MFIS and its subscales; however, some studies, such as those by Kos et al. (2005); Téllez et al. (2005), use a total score of 38 as a point of reference to differentiate between fatigued and non-fatigued individuals (Larson, 2013).

Karolinska Sleepiness Scale

The Karolinska Sleep Scale (KSS) is a widely used tool in studies of shiftwork, sleep deprivation, and driving (Kaida et al., 2006; Miley et al., 2016). The KSS requires research participants to rate their perceived sleepiness in the 10-minutes prior to the assessment on a 9-point rating scale (Shahid et al., 2012). This 10 minute time frame measures situational sleepiness as an individual’s perception of sleepiness is sensitive to fluctuations over a day (Shahid et al., 2012). Ratings from the scale may influence how individuals cope with and perceive sleepiness (Gillberg et al., 1994). However, the scale does refer to behavioural criteria (e.g. fighting sleep, the effort to keep awake) that could potentially be easier to recognise and understand by different individuals (Åkerstedt et al., 2014). The simple design of the KSS and the rapid response time required to complete the assessment is the motive for utilising it in this study, as it did not significantly interrupt the participant's work processes.

3.4.3. Environmental and Work output recordings

Part two of the repeated assessment included recording environmental conditions and work output data. This was to acknowledge the working context and the circumstance under which the subjects performed their work. To do so, the researcher made use of a self-developed environmental and work output survey to record environmental and work-related factors that are known to vary over time (Appendix A.4). This information was recorded repeatedly throughout the harvesting season on the same day as participants' fatigue assessments were conducted.

Environmental factors that were assessed included temperature, noise levels, and lighting intensity. Internal ambient temperatures of the packhouse were recorded, as it has been noted that prolonged exposure to extreme temperatures may impact the influence of fatigue (Techera et al., 2016). The temperature was recorded using a thermometer (Major-Tech MT667). Similarly, extreme noise levels are known to affect the alertness and vigilance of employees performing tasks, where exposure over a lengthy period can result in increased general levels of fatigue (Åhsberg, 1998; Lerman et al., 2012). Noise levels were recorded using a sound level meter (EXTECH instruments 407730). Lighting intensity at the different sorting stations was recorded using a lux meter (Major-Tech MT940) which was held facing upwards at the level of the fruit on the conveyor belts. Lighting intensity has been shown to significantly affect perceived sleepiness levels (Dawson et al., 2011). Low lighting intensities are also known to increase eye strain as detecting defective fruits in low contrast for citrus sorters is more complicated (Bollen & Prussia, 2014).

Questions regarding the work output were obtained from the packhouse supervisors and included shift start and end times; the number of sorters per shift; the number of crates offloaded; and the length of rest breaks. This information was considered vital as these are workload indicators, which could impact the work pressures experienced by participants and may, in turn, contribute to fatigue development.

3.5. ETHICAL CONSIDERATION

Before the start of the study and the distribution of the survey for phase one, an ethics application was reviewed and approved by the Rhodes University's Human Ethics Committee (tracking number: 2022-5389-6652) (Appendix B.1). This ethics application addressed issues about informed and voluntary consent, risks, and benefits of the study, anonymity, and confidentiality of data. A letter of information was provided to packhouse management (Appendix B.2) to grant gatekeeper permission, after which sorters were recruited to participate in the study. All participants were issued a letter of information (Appendix B.3), which was also presented verbally to the participants. A consent form (Appendix B.4) was signed by sorters who agreed to participate in the research study. Participation was voluntary for all the participants.

3.6. PROCEDURES

Once ethical approval and gatekeeper permission for the study had been obtained, participants were recruited and informed about the different parts of the study. Questions that participants may have had were answered to their satisfaction, the consent forms were signed, and participants were told when the study would commence. The procedures for this study were the same for both the day and night shifts.

The first part of the study involved administering the background questionnaire. Each participant was required to complete this questionnaire. Participants were individually relieved temporarily from their sorting stations by packhouse supervisors. They completed the questionnaire in a conference room near the sorting station, which allowed for minimal interruptions of the sorting lines. The researcher was present while the participants completed the survey in case there were any queries or misunderstandings of specific questions. The participants would return to their sorting stations after completing the questionnaire, and the next participant would follow. Upon the request of packhouse management, this survey was conducted two weeks into the harvesting season (31 May 2022) to allow employees to settle into the working rhythm first before the minor disruptions of the study. Codes were allocated to each participant to ensure anonymity.

The second part of the study began on 8 June 2022 and ended at the end of the harvesting season (21 September). The researcher visited the packhouse in 3-week intervals, totalling six visits for the season. Similar to the first part of the study, participants were taken off the sorting line individually to complete the repeated assessment in the conference room to provide participants with privacy while completing the assessment. The researcher was again present during their assessment to answer any queries or misunderstandings to specific questions. Testing of the day-shift participants began at 14h30 while testing for night-shift participants commenced at 01h00. Due to logistical reasons, including absenteeism and the time it took to administer the fatigue assessment on a one-on-one basis, the day-shift participants were split into two groups, with testing taking place on consecutive days. These groups were to be kept consistent throughout the study duration. Furthermore, only one group on the night shift was assessed. The researcher completed the environmental and work output recordings as they did not require input from the participants. It was completed at the end of the shift, so information such as "number of crates offloaded" and "number of sorters per sorting room" could be obtained from the supervisors.

3.7. STATISTICAL ANALYSES

The data captured for each participant's responses were compiled into a single Microsoft Excel spreadsheet. Data underwent a cleaning and reduction process before they were analysed. This cleaning process involved identifying outliers or invalid responses. The nominal data were then converted into numerical values to enable statistical analyses to be performed. Furthermore, repeated measures analyses would not be possible if participants had left out a single data point for a given variable (e.g., because of being absent on the day). They would lead to several datasets being excluded from the entire analysis for the variable. To prevent this, missing data were inserted by averaging the two adjacent scores for the missing data point (e.g., if the week two physical subscale score was missing, week one and week three physical subscale scores were averaged to substitute for the missing week two data point). While this practice comes with limitations and given the paucity of information on fatigue development in this context, the assumption was made that fatigue responses increased linearly and substituting the missing data points with an average value of the adjacent data points was considered appropriate. Data substitution was considered reasonable only if participants had missed one data point (e.g., one day). If they had missed more than one data point for a given variable, they would be excluded from that analysis. The data were then transferred into the Statistica Software, *Model: Statistica 14 ©, TIBCO Software Inc. Version no. 14.0.0.15. USA (1984-2020)* for statistical relations to be assessed. Initial descriptive statistics such as the mean, mode, median, standard deviation, and coefficient of variation were calculated for the different variables and the different days of data collection. These descriptive statistics were conducted on all variables within the generic questionnaire, the fatigue assessment, and the environment and work output results. Additionally, categorical data were converted into percentages to allow for comparison and interpretation.

The Shapiro-Wilks test for normality distribution was used to select the most appropriate tool for inferential statistics. Data sets with $p>0.05$ are normally distributed, whereas $p<0.05$ are regarded as not normally distributed. When the Shapiro-Wilks analysis confirmed normality, a GLM model analysis was used to identify the differences across weeks, shifts, and individual scores for the MFIS and KSS datasets. A GLM analysis provides multiple linear patterns for the continuous response variables and graphically displays the distribution of the different datasets (Brown & Prescott, 2014). Furthermore, the GLM is considered a mixed methods analysis model with which both normally and non-normally distributed data can be evaluated (Brown & Prescott, 2014). The confidence level was set at 95%, meaning significant differences were identified at a p-value of less than 0.05. Any significant differences identified underwent Tukey post-hoc analyses to determine where the differences lay at $p<0.05$.

Pearson's Product-Moment correlations were also conducted to determine any associations between the fatigue responses and the individual and work-related factors. The relationships between two variables are denoted by the letter r and expressed by a value that ranges between -1 and 1 (Akoglu, 2018). 0 signifies no correlation, while a value that is 1 or close to is considered a strong or perfect correlation. Akoglu (2018) indicates that $0 < r > 0.4$ is considered weak, $0.4 < r > 0.7$ is moderate and $0.7 < r > 1$ is regarded as strong. These statements are the same when the r value has a negative correlation. The p-value was set again at 0.05 to identify any significant correlations.

CHAPTER 4: RESULTS

4.1. WORK SYSTEMS DESCRIPTION

Four citrus companies were contacted within the Sundays River Valley (SRV) and were invited to participate in the study. Of these, only one citrus company permitted the study to be conducted in their packhouse. The majority of the workers employed in the packhouse were sorters and packers, plus some managerial and support staff. The packhouse worked on a five-day per week work schedule (Monday-Friday) and employed a two-shift system. Day shift employees commenced work at 07h00 and ended at 17h00. Three breaks were also provided: one being 20 minutes (09h00-09h20), another being 10 minutes (15h00-15h10), as well as a 45-minute lunch break (12h00-12h45). For the night shift workers, working hours ran from Monday to Friday from 18h00 to 06h00, with three breaks. These breaks consisted of two 30-minute breaks (21h00-21h30 & 00h00-00h30) and one 20-minute break (03h00-03h20). Workers were allocated to the day or night shift; there was no rotation in the shift schedule. No work was generally required on weekends, although increased citrus supply, usually around the peak of the harvesting season, sometimes required sorters and packers to work overtime on weekends.

The packhouse operation began with unloading bulk fruit bins directly from the orchard onto the packing line (Simcox et al., 2001). Each bulk bin was tipped at a constant rate, creating a constant flow of fruit received at the pre-sorting station outside the packhouse. At the pre-sorting station, the pre-sorters' task was to identify all apparent fruits that would not conform to local or international marketing standards. Apparent indications of non-conforming fruits were rotten or split fruits which were removed before the washing process to prevent contamination of other fruits. After washing, the remainder of the fruits continued along the packing line for pre-sizing, washing, drying, and waxing before reaching the main sorting stations. The sorting stations of the packhouse consisted of different sorting lines (so-called "rooms") that the employees were allocated. These rooms were designed to allow for different varieties of citrus (e.g., Lemons, Clementines, Navels, Deltas, Valentia's, etc.) to be sorted and were thus flexible to the variable volumes and citrus types harvested throughout the season rather than having one bulk flow of fruit to be sorted simultaneously. Once workers were allocated to a specific room, they would remain in that room for the entire harvest season. Three rooms in the packhouse were accessed for the current study. Within each room, the task cycle of the sorters included: 1) monitoring the quality of the incoming fruits, 2) deciding on the grade of the fruit, 3) reaching to pick out and discard defective fruits from the conveyor and placing them into the discard chute, and 4) monitoring the fruits as they move to the next station. This task cycle was repeated a few thousand times per shift.

Sorters were also required to perform additional tasks when the production line was placed on hold, such as cleaning and sanitizing their workstation. After sorting, the fruits would then be sized and graded by a machine that would direct the fruit to the appropriate packing lines according to the standards set by international markets. The fruit was packed according to the international client's specifications, as packaging needed to adhere to their demands. Fruit would either be wrapped in paper, packed in a specific pattern, have stickers, or have no packaging request at all. Once filled with citrus fruit, the boxes were then palletized, and a final inspection of the load would occur before being transported to the harbours to be shipped off to the destined countries.

4.2. PARTICIPANT SAMPLE

Verbal and written consent were obtained from 39 citrus sorters working in this citrus packhouse within the SRV. During the harvesting season, two participants were promoted, and two further participants resigned from their occupations. Therefore, they were excluded from the study, resulting in 35 individuals who participated for the entire study duration. However, it should be noted that work attendance varied from week to week because of absenteeism or other personal factors, thus affecting the overall sample size for each week of data collection. Of the participants that were included in the study, 19 were day shift workers, and 16 were night shift workers. The descriptive statistics of the participants were recorded, and detailed tables can be found in Appendix C.1. A summary of the participants' demographic profiles is presented in Table 1.

Table 1: Summary of participants' demographic profile (n= 35). Results are presented as frequencies (percentage in brackets) or means (± standard deviation).

Gender	Female – 35 (100%)
Average age (years)	38 (±8.78)
Home language	English – 1 (3%) isiXhosa – 26 (74%) Afrikaans – 1 (3%) Bilingual – 7 (20%)
Race	'Black'/ African – 33 (94%) 'Coloured' – 2 (6%)
Marital status	Single/ Unmarried – 29 (84%) Married – 4 (11%) Widow – 2 (5%)
Number of dependents*	Children – 2 (±1.54) Elderly – 1 (±1.53)
Highest level of education	Grade 9 – 2 (6%) Grade 10 – 9 (25%) Grade 11 – 18 (53%) Grade 12 – 5 (17%)
Chronic illnesses	Yes – 12 (34%) No – 22 (63%) Prefer not to say – 1 (3%)
Perceived health status	Very poor – 0 (0%) Poor – 0 (0%) Fair – 4 (11%) Good – 20 (57%) Very good – 11 (31%)
Substance use	Yes – 2 (6%) No – 23 (66%) Sometimes – 8 (23%) Prefer not to say – 2 (6%)
Exercise	Daily – 3 (9%) Three times per week – 0 (0%) Once a week – 10 (29%) Once a month – 4 (11%) Never – 16 (46%) Prefer not to say – 2 (6%)

* *Means are rounded to the nearest whole number*

All participants included in the study were female (n= 35), of which the majority identified as being 'Black'/African (94%), while only two (6%) classified themselves as 'Coloured'. The mean age of all citrus sorters was 38 years, with the youngest participant being 24 and the oldest 59 years old, thus indicating a considerable variation in the participants' ages (SD= 8.78 years; CV= 23.11%).

Regarding marital status, 29 participants (84%) classified themselves as single or unmarried, while two participants (5%) were widowed. Thus, only four (11%) workers were in a relationship such as being married or having a partner. With this in mind, sorters had, on average, two (±1.54) children and one elderly individual (±1.53) living within the same household and who would most likely also be dependent on the worker's income. Only five (17%) sorters had completed their secondary school education (Grade 12), while the remainder (83%) had not finished their secondary schooling.

The questions about general health revealed that 31 (89%) participants perceived their health to be 'good' or 'very good', while the remaining four sorters classified their health as 'fair'. This high level of perceived health may be attributed to the fact that 23 (66%) participants did not drink alcohol, smoke, or use any other substances. However, 10 (29%) participants did admit to using such substances. Despite the high levels of perceived health, approximately one-third of participants acknowledged that they suffered from a chronic illness (e.g., HIV, diabetes, cardiovascular disease, arthritis, hypertension). Additionally, 20 (57%) participants said they never exercised in their free time or exercised only once a month, while only 13 (38%) participants engaged in physical exercise at least once a week.

The results relating to work-specific factors (Table 2) revealed that participants had, on average, 9.3 years of experience as sorters, although this varied significantly (±8.57 years) as some sorters only had two years sorting experience, while others had as many as 36 years of experience. The average participant had been employed for 12.4 years at that packhouse, although this too varied significantly (±7.97 years). The longest-employed sorter in the sample had worked in the packhouse for 36 years, compared to the three years of employment for the participants with the least number of years employed. When asked whether they had received any formal training before the start of the harvesting season, only six (18%) workers confirmed that they had received some form of training. In comparison, the remaining 28 (82%) participants indicated they had not received any. It is unknown whether on-the-job training occurred.

Table 2: Summary of participants' work-related information (n= 35). Results are presented as frequencies (percentage in brackets) or means (±standard deviations).

Years employed at the packhouse	12,4 (±7.97)
Years employed as a sorter	9,3 (±8.57)
Transport to work	Company – 35 (100%)
Overtime required?	Yes – 0 (0%) No – 1 (3%) Sometimes – 33 (94%) Did not answer – 1 (3%)
Training received?	Yes – 6 (17%) No – 28 (80%) Did not answer – 1 (3%)
Additional job worked?	Yes – 2 (6%) No – 32 (91%) Did not answer – 1 (3%)

All participants used transport provided by the packhouse company to travel to and from work as part of their employment agreement. Finally, only two participants (6%) held down another job in addition to that at the packhouse.

4.3. NORMALITY TESTING

The data from the Karolinska Sleepiness Scale (KSS) and the Modified Fatigue Impact Scale (MFIS) were tested for normality to determine whether parametric or non-parametric statistical testing should be conducted. The Shapiro-Wilks test for normality was applied to the entire data set and the day and night shift workers' data separately. Furthermore, the three dimensions of the MFIS data are presented separately. The outcomes of the Shapiro-Wilks test for the MFIS and the KSS can be found in Appendix C.2.

The MFIS scores were normally distributed across all weeks except for week six. When assessing normality across the different shifts, it was found that the day shift data were normally distributed, except for week six. In contrast, the night shift data were not normally distributed except for week six. Furthermore, the MFIS data were separated into the different subscales (physical, cognitive, psychosocial), and normality was again assessed amongst all participants, and the different shifts. It was discovered that the data were primarily normally distributed for the physical and cognitive subscale for all participants and both shifts. However, normal distributions for the psychosocial sub-scale were less common, irrespective of shift.

Finally, when testing for normality of the overall KSS scores for all participants, it was found that all weeks were normally distributed, except again for week six. Normality analyses of the KSS scores for the different shifts indicated that only the day shift generally presented normally distributed data. In contrast, the night shift mainly presented non-normally distributed data.

4.4. MODIFIED FATIGUE IMPACT SCALE

Descriptive statistics (Appendix C.1) were calculated to provide a comprehensive overview of the MFIS data throughout the data collection period. The sample size changed throughout the different weeks for various reasons, such as a particular shift not working that week, absenteeism, or participants unwilling to complete the questionnaire. Table 3 provides a summary of the overall MFIS scores for all the participants over the different weeks of the research testing.

Table 3: Summary of statistics of the overall MFIS scores (absolute scores) for all participants (means; ±SD; CV). Numbers in brackets indicate the number of responses (n) obtained.

	TOTAL MFIS SCORE
WEEK 1	36.61; ±14.18; 38.74% (28)
WEEK 2	36.84; ±14.02; 38.06% (25)
WEEK 3	41.77; ±14.92; 35.72% (28)
WEEK 4	39.27; ±13.55; 34.51% (33)
WEEK 5	40.41; ±13.19; 32.65% (32)
WEEK 6	39.71; ±13.46; 33.89% (31)

* *The weeks refer to the research testing weeks rather than the consecutive calendar weeks.*

Further analyses were conducted using a GLM to assess the effect of the type of shift (day vs night) and time (weeks) on the overall MFIS scores to determine whether the two shifts experienced different fatigue levels throughout the collection period. Figure 3 shows that the day shift exhibited a greater overall MFIS score throughout the season than the night shift. Day shift participants' MFIS scores gradually increased from the start of the season until week four, after which a moderate decline in scores was recorded for the final two weeks. However, the MFIS scores gradually rose over the entire collection period for the night shift workers. No significant differences were however found between the shifts (p= 0.209) and weeks (p= 0.112), nor was there an interaction effect between these two factors (p= 0.640) (see Appendix C.3). The fatigue threshold (MFIS score of 38) is presented in Figure 3 as the dotted line. This threshold was surpassed in all the weeks for the day shift participants but was only exceeded in the final two weeks for the night shift participants.

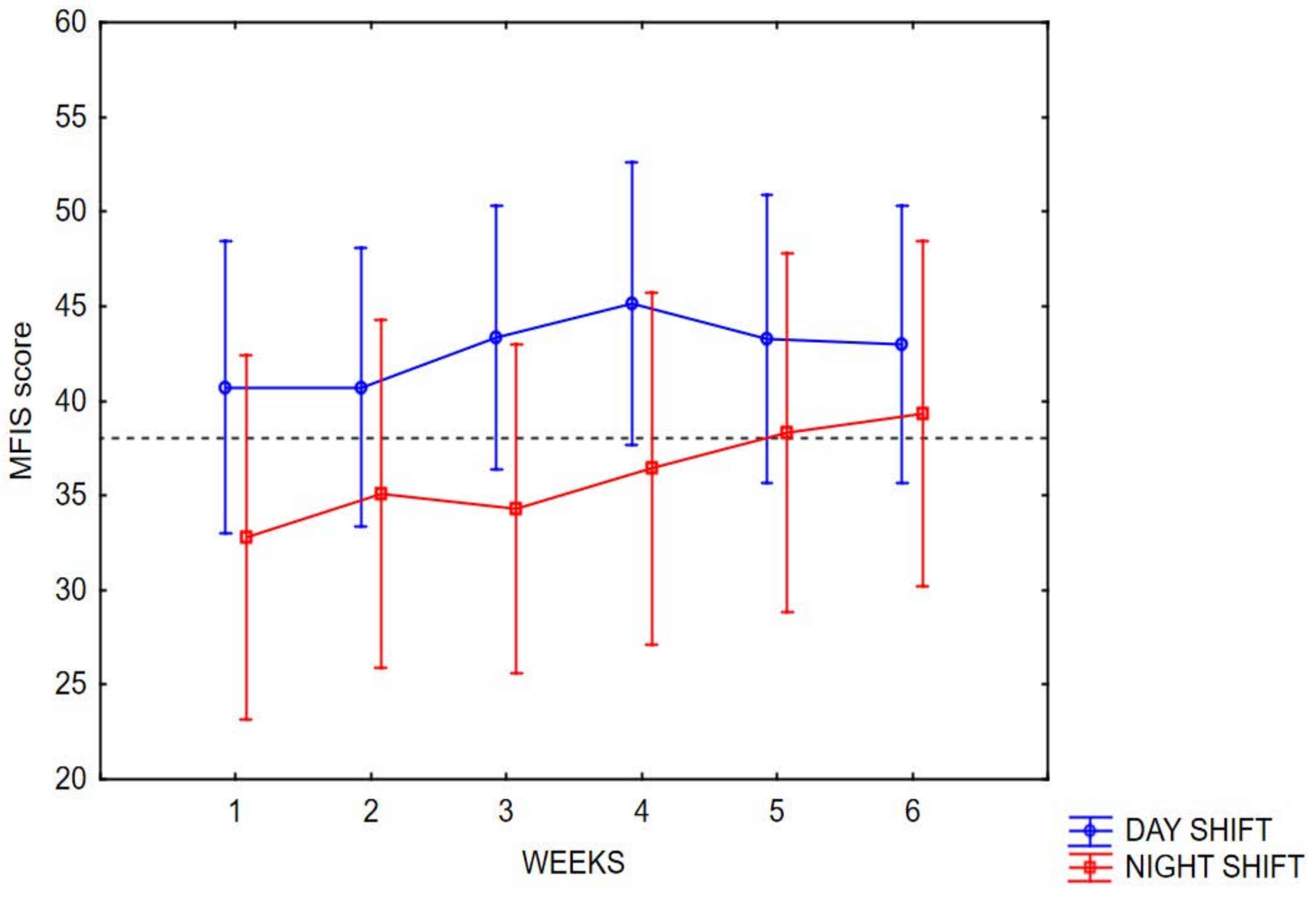

Figure 3: Average MFIS scores comparing the day and night shifts over weeks. The dashed line indicates the fatigue threshold.

4.4.1. MFIS subscale scores

For further analyses of the MFIS scores, the subscale scores of the MFIS were compared across weeks for all participants to determine whether any changes occurred in any of the subscales over time. This would determine which domain (physical, cognitive, and psychosocial) was most affected by fatigue. Figure 4 indicates the contributions of the physical, cognitive, and psychosocial subscales towards the overall MFIS score.

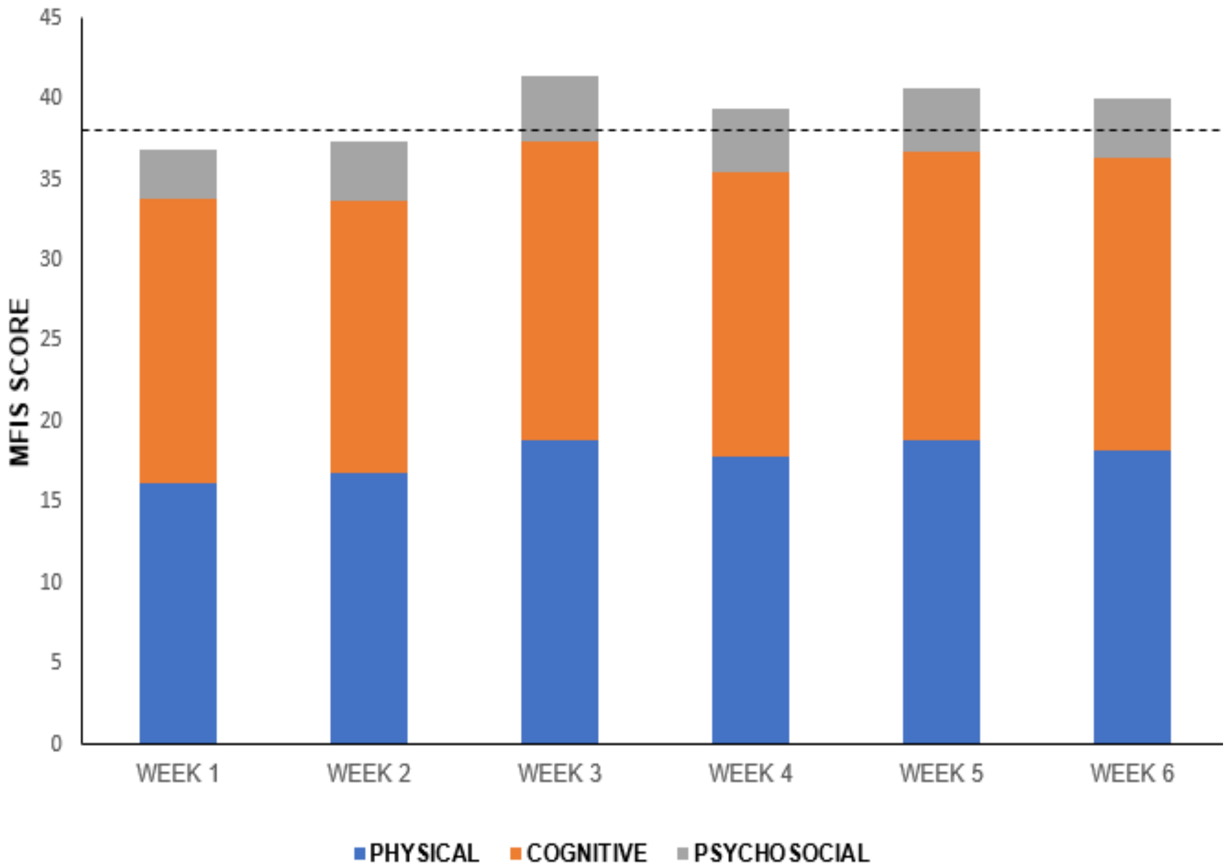

Figure 4: Stacked bar graph of the mean overall MFIS subscale scores across weeks. The dashed line indicates the fatigue threshold.

The MFIS assessment consists of 21 questions, and the overall MFIS score is a composite score of all the subscale scores. The cognitive and psychosocial subscales displayed no significant differences over the weeks ($p = 0.183$ and $p = 0.375$ respectively), but there was a significant difference recorded for the physical subscale over the six weeks ($p = 0.021$). A Tukey post-hoc test was run to identify where the significant difference in the physical subscale was located and revealed that the difference lay between week one and week five ($p = 0.033$).

However, each subscale contains a different number of questions (i.e., nine questions relating to the physical domain, ten questions to the cognitive domain, and two for the psychosocial domain), which is why the psychosocial scores were considerably lower than the physical and cognitive scores. Comparing the three subscale scores within

each week to one another was, therefore, not possible. Instead, the relativized scores of the subscales were calculated to allow for an appropriate comparison.
To enable comparisons of the different fatigue subscales, each score was calculated as a proportion of the subscale's maximum score. In other words, the score for the week was divided by 36 (maximum total for the physical subscale) and then multiplied by 100 to calculate its percentage. For the cognitive subscale, the score was divided by 40; for the psychosocial subscale, the score was divided by eight. The summary statistics for the MFIS subscale scores are depicted in Table 4.

Table 4: Summary statistics for all participants' relativized MFIS subscale scores across weeks (means; ±SD; CV), with numbers in brackets indicating the number of responses (n) obtained.

	MFIS SUBSCALE SCORES (relative scores in %)		
	PHYSICAL	**COGNITIVE**	**PSYCHOSOCIAL**
WEEK 1	44.82; ±17.30; 38.60% (34)	44.05; ± 21.80; 49.48% (29)	38.60; ±23.90; 61.94% (34)
WEEK 2	46.86; ±16.21; 34.60% (27)	42.01; ±19.06; 45.37% (27)	46.73; ±19.77; 43.27% (29)
WEEK 3	52.49; ±17.76; 33.84% (29)	46.25; ±17.90; 38.70% (29)	50.00; ±20.30; 40.60% (30)
WEEK 4	49.58; ±15.84; 31.94% (33)	43.86; ±18.60; 42.41% (33)	48.48; ±20.91; 43.12% (33)
WEEK 5	52.09; ±16.53; 31.74% (33)	44.84; ±16.16; 36.04% (32)	48.48; ±21.13; 43.60% (33)
WEEK 6	50.71; ±16.28; 32.09% (31)	45.16; ±18.12; 40.12% (31)	45.56; ±22.54; 47.28% (31)

** The weeks refer to the research testing weeks rather than the consecutive calendar weeks.*

The results in Table 4 indicate that all participants' physical subscales displayed greater mean scores and lower standard deviations across all weeks compared to the cognitive and psychosocial subscales. The highest mean score of the physical subscale was seen in weeks three (52.49) and five (52.09), where week three also resulted in the highest relativized MFIS scores for the cognitive and psychosocial subscales. When comparing the subscales with one another, it was found that there was no significant difference between the different subscales (p= 0.528), nor was there an interaction effect of weeks and subscales (p= 0.973). However, time (i.e., weeks) did have an effect (p= 0.003), with a Tukey post-hoc test indicating a significant difference between weeks two and three (p= 0.001).

Further comparisons of the MFIS subscales were conducted between the different shifts and how their scores may have changed over time. Each subscale was assessed separately (Figure 5 displays the physical, Figure 6 displays the cognitive, and Figure 7 displays the psychosocial subscale scores) to allow for comparisons between shifts.

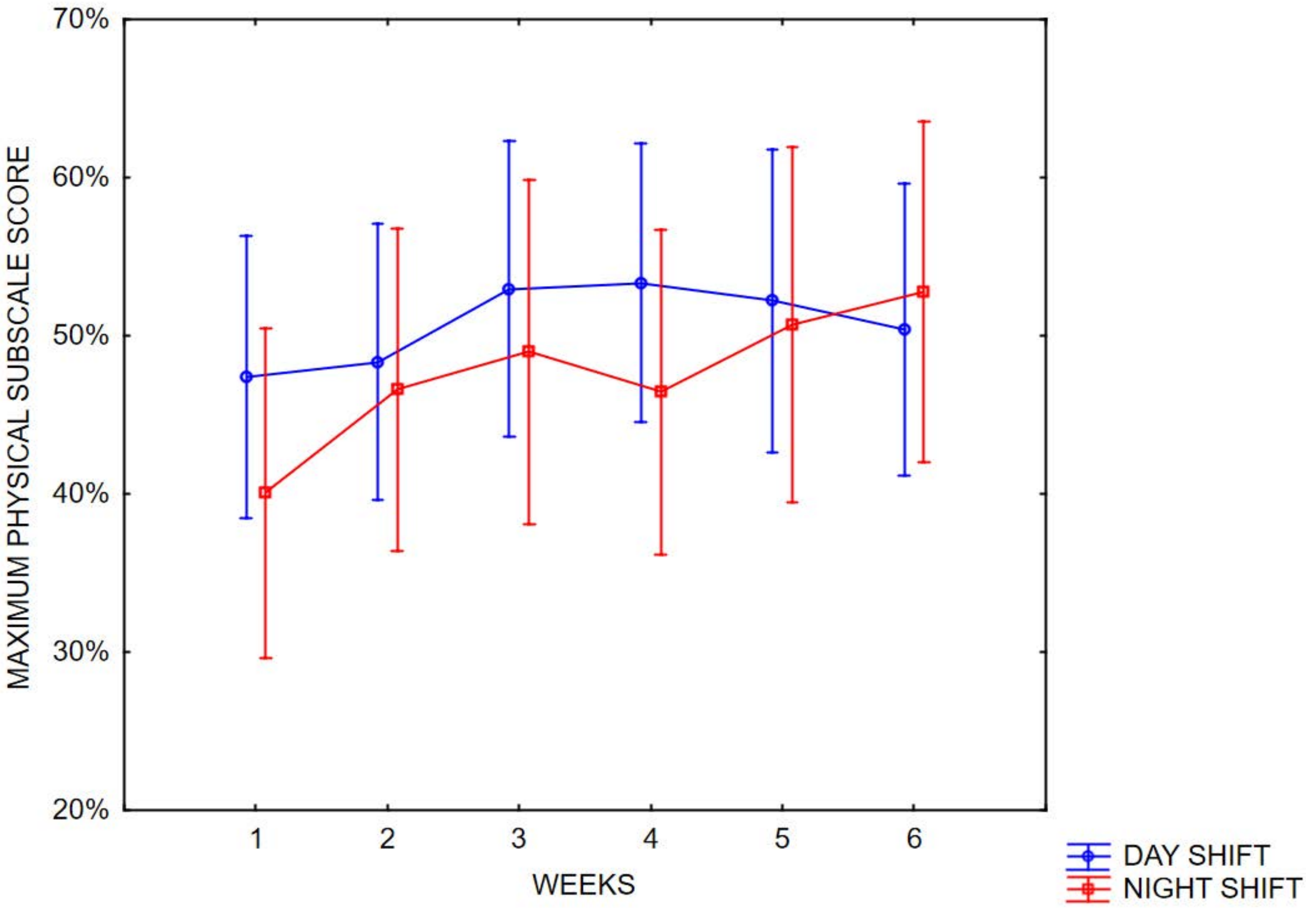

Figure 5: General Linear Model of the relative physical MFIS subscale score between the different shifts.

The physical subscale registered the highest maximal percentages across all weeks compared to the other subscales. Throughout the season (except for week six), the day shift workers recorded greater mean physical MFIS subscale scores than compared to the night shift. The day shift workers' highest maximal physical subscale percentage was recorded in week three (55.21%), while the night shift's highest percentage was in week six (51.39%). The sample size varied considerably between the two shifts across the different weeks for the physical subscale; however, the variability remained relatively consistent between the two shifts. In addition, the physical subscale was the only subscale to record a significant difference over time ($p= 0.033$). This difference originated between week one and week five.

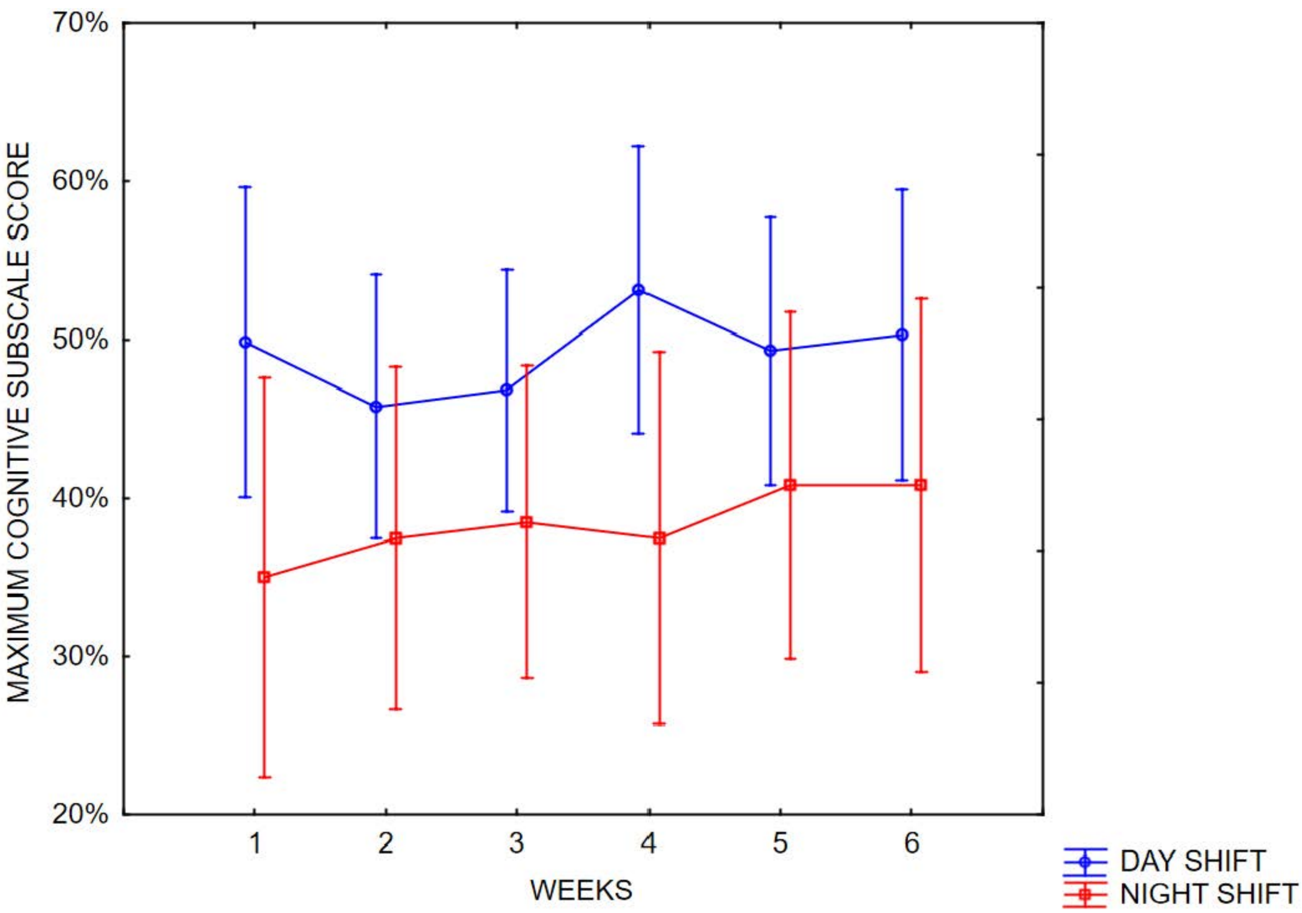

Figure 6: General Linear Model of the relative cognitive MFIS subscale score between the different shifts.

For the cognitive subscale, the day shift workers produced greater mean MFIS percentages across all weeks than the night shift. The highest cognitive MFIS score for the day shift was in week four (51.39%), while the highest score for the night shift was in week five (42.81%). The night shift, however, displayed greater variability within their cognitive scores across all weeks. Additionally, it was recognized that the cognitive subscale showed no significant between weeks or shifts, nor an interaction effect.

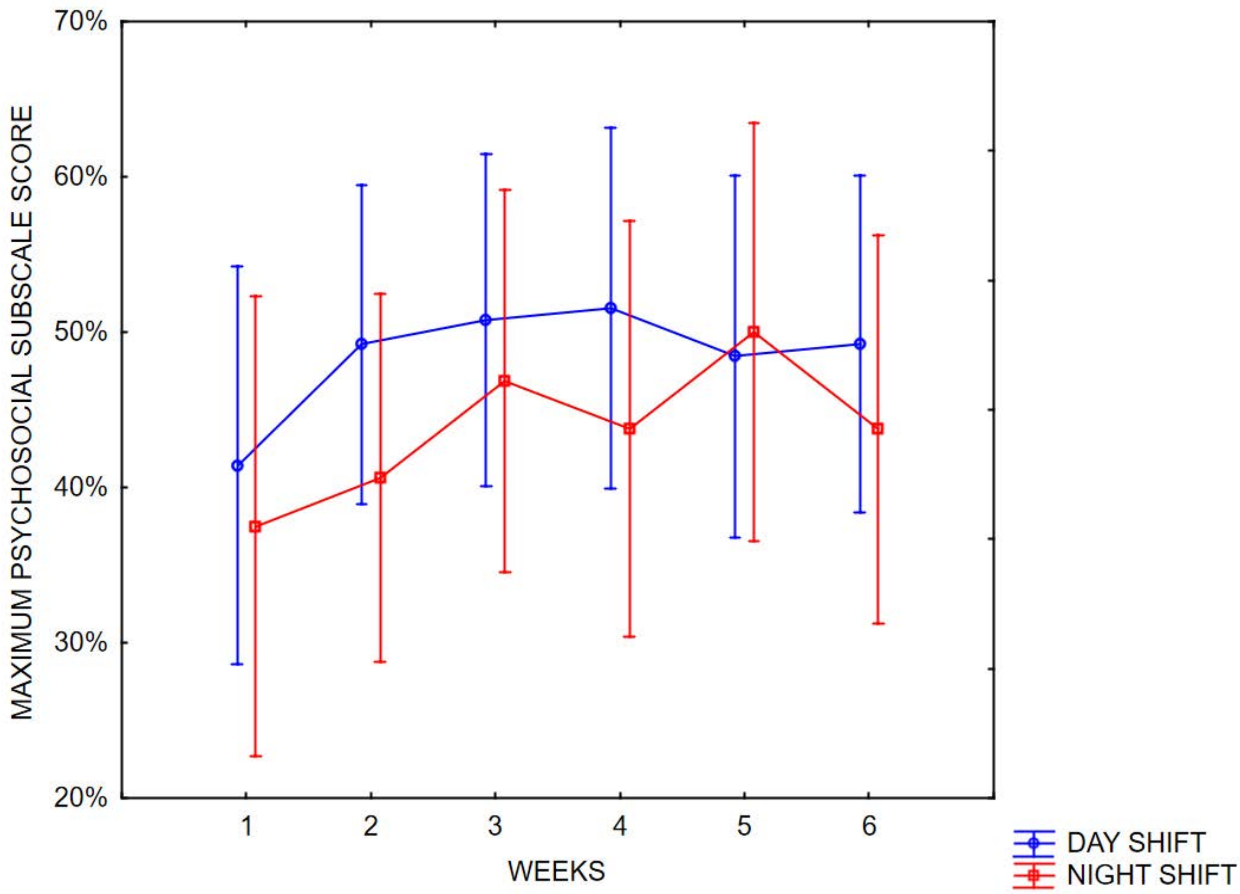

Figure 7: General Linear Model of the relative psychosocial MFIS subscale score between the different shifts.

The day shift workers reported greater maximal psychosocial subscale percentages across all weeks except for week five. In week four, the day shift workers recorded the highest maximal percentage (52%), whereas the night shift workers' highest percentage was recorded in week five (50%). It was found that the psychosocial subscale provided no significant difference in the effects of shifts, in the effects of weeks, nor was there an interaction effect between weeks and shifts.

For all sub-scales across all the weeks, except week six of the physical subscale, the day shift experienced higher relative mean MFIS scores than the night shift, meaning that the day shift workers experienced greater fatigue across all different subscales than the night shift workers. However, when analysing all the subscales, there was no statistically significant effect for shifts, and weeks, nor was there an interaction between weeks and shifts.

4.5. KAROLINSKA SLEEPINESS SCALE

The Karolinska Sleepiness Scale (KSS) was used to identify participants' perceived levels of sleepiness. Descriptive data were calculated using all KSS scores over the different weeks and for both shifts. The higher the value of the KSS score, the greater the perceived sleepiness. Geiger Brown et al. (2014) indicated that values on the KSS above seven represent high levels of perceived sleepiness.

The summary statistics in Table 5 show that the participants' average KSS scores ranged from 4.72 to 5.33 (out of a maximum of nine) over the six weeks of data collection. The lowest mean score was captured in the first week, while the highest was in the final week of data collection. There was, however, considerable variability in the data, with CV values ranging between 45.53% and 55.80%. Furthermore, it was found that there was no significant difference in the KSS scores over the six weeks (p= 0.885).

Table 5: Summary statistics for KSS scores of all participants (means; ±SD; CV). Numbers in brackets indicate the number of responses (n) obtained.

	AVERAGE KSS SCORES
WEEK 1	4.72; ±2.63; 55.74% (32)
WEEK 2	5.15; ±2.34; 45.53% (31)
WEEK 3	4.88; ±2.72; 55.80% (30)
WEEK 4	5.21; ±2.47; 47.47% (34)
WEEK 5	5.00; ±2.39; 47.89% (31)
WEEK 6	5.33; ±2.63; 49.32% (30)

** The weeks refer to the research testing weeks rather than the consecutive calendar weeks.*

During none of the six weeks did the average score of all the participants surpass the threshold of high levels of perceived sleepiness. However, when analysing the data individually, it was seen that eight participants (22.22%) had an average KSS score of seven or greater over the season. This would indicate that a small proportion of the participants did perceive excessive sleepiness each week throughout the season. Further analyses were conducted on the KSS scores to determine whether there were any differences in sleepiness across weeks, between the shifts, or if there was an interaction effect (Figure 8).

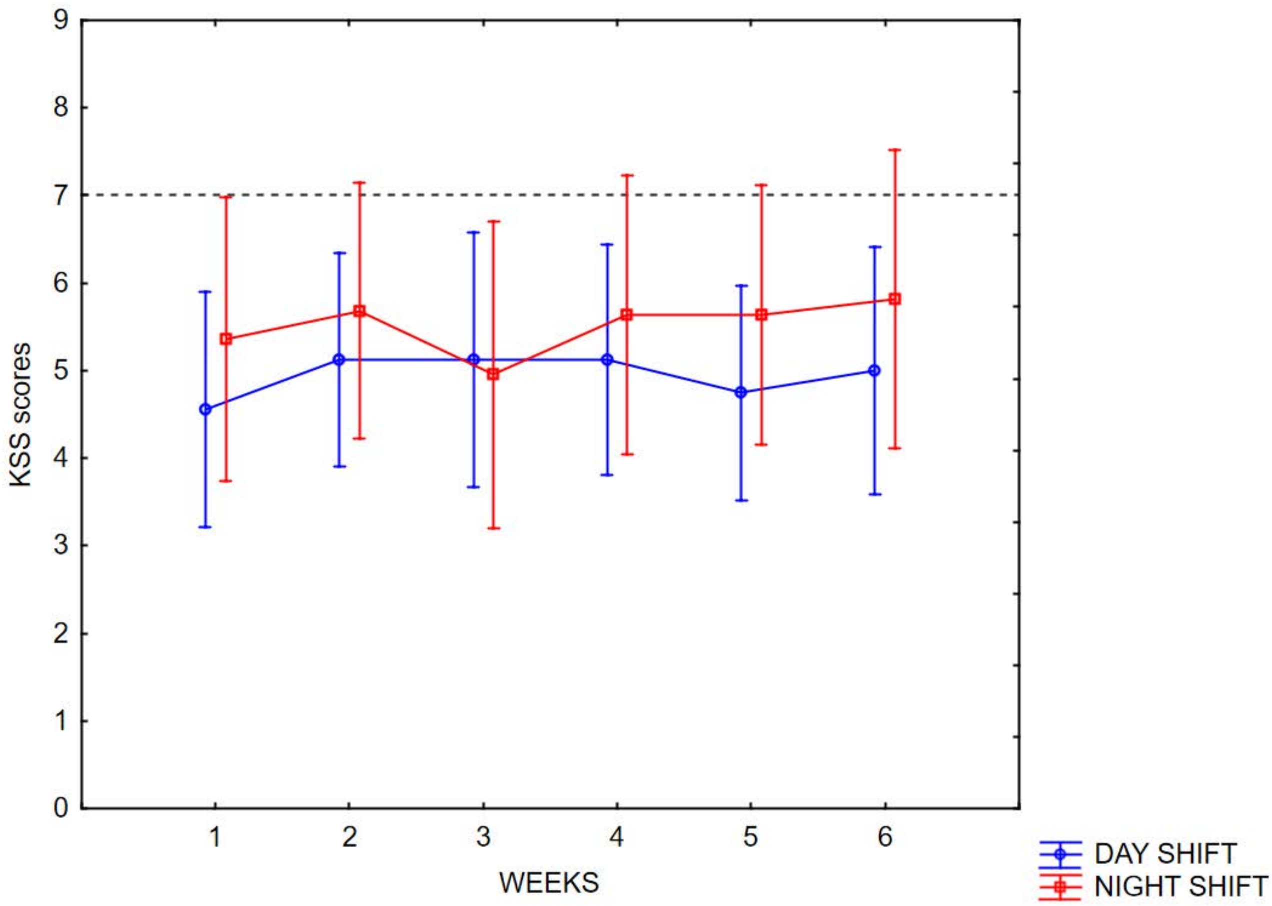

Figure 8: General Linear Model of the average KSS scores between the different shifts. The dotted line depicts the threshold for excessive sleepiness.

The highest mean sleepiness score (5.71) was experienced by the night shift workers in the last week of the data collection period, while the day shift workers experienced the lowest mean score (4.41) in the first week. When comparing the shifts with one another, the participants from the night shift reported marginally higher KSS scores than the day shift workers throughout the study duration, except for week three. However, there was no statistically significant difference between shifts ($p = 0.489$). The KSS scores for the day shift were relatively consistent across the weeks, while the responses for the night shift were more variable from week to week, with a noticeable drop in week three. Additionally, there was no significant difference in KSS scores between weeks ($p = 0.883$) nor an interaction effect between weeks and shifts ($p = 0.885$).

4.6. WORK PERFORMANCE

In addition to the fatigue and sleepiness scales, participants were asked questions that may provide insights into factors that could have influenced perceptions of fatigue and sleepiness while at work. These factors were separated into individual factors and work-related factors.

4.6.1. Individual factors

Sleep

Sleep ensures adequate recovery from the demands of the previous day's work and is essential for effective work performance and worker well-being (Kajtna et al., 2011). Table 6 details the participants' wake-up times for the different shifts on the measurement days, as well as the number of hours of sleep that participants obtained during the week of each data collection period.

Table 6: Descriptive data of participants' sleep information (means; ±SD). Numbers in brackets indicate the number of responses (n) obtained.

		WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6
WAKE-UP TIME (HRS: MIN)	**DAY SHIFT**	04:24; ±0.44; (19)	04:25; ±0.41; (19)	04:36; ±0.33; (9)	04:33; ±0.37; (19)	04:29; ±0.38; (17)	04:34; ±0.42; (18)
	NIGHT SHIFT	13:53; ±1.17; (16)	14:04; ±0.73; (7)	14:11; ±0.69; (13)	14:16; ±1.08; (16)	12:07; ±2.28; (16)	12:04; ±2.48; (14)
DURATION OF SLEEP PER WEEK (HRS: MIN)	**DAY SHIFT**	8:11; ±1.24; (19)	7:58; ±1.34; (19)	8:30; ±1.46; (9)	7:55; ±1.25; (17)	8:04; ±1.05; (16)	8,09; ±1.25; (17)
	NIGHT SHIFT	7:28; ±1.67; (14)	6:42; ±0.45; (5)	6:48; ±1.12; (12)	6:53; ±1.51; (16)	7:13; ±1.40; (16)	6:55; ±1.13; (13)

** The weeks refer to the research testing weeks rather than the consecutive calendar weeks.*

Waking times were only compared between the weeks within each shift due to evident differences in the wake-up times for the two shifts. Over the six weeks of the data collection, the day shift workers' average wake-up time was 04h30, while the average wake-up time for the night shift workers was 13h33. The day shift found no significant difference in waking times across the weeks of the harvesting season ($p= 0.762$), nor did the night shift ($p= 0.151$), which could be attributed to the considerable variability in waking times. For example, during the last two weeks of the data collection, participants from the night shift woke up two hours earlier than in the other weeks.

The number of hours of sleep per week obtained by the participants could be compared between the two shifts. Overall, the day shift workers received more sleep than the night shift workers, as they obtained higher average hours of sleep across all weeks over the study duration. The day shift received their highest number of hours slept in week three (8:30 hours), while the night shift workers received their highest number of hours slept in week one (7:28 hours). It was found that there was no effect of time (i.e., weeks) nor an interaction effect between weeks and shifts ($p= 0.403$). However, there was a significant difference in the hours of sleep received between shifts ($p= 0.011$).

Caffeine consumption

Caffeine is the most common self-administered countermeasure against sleepiness and fatigue in the occupational setting to ensure that work performance is not hindered (Schutte, 2006). Participants responded to questions with either “Yes” or “No” if they had consumed any caffeinated beverage before their shift started or during their shift breaks during the measurement weeks. This could provide insight into whether participants used caffeine as a strategy to combat symptoms of fatigue. Table 7 provides an overview of the caffeine consumption before and during the shift of all participants and the different shifts they work in.

Table 7: Summary of the proportion of participants consuming caffeine throughout the harvest season.

	ALL PARTICIPANTS	DAY SHIFT	NIGHT SHIFT
CAFFEINE BEFORE THE SHIFT	YES= 61.35% NO = 38.57%	YES= 66.35% NO= 33.65%	YES= 54.68% NO= 45.33%
CAFFEINE DURING THE SHIFT	YES= 56.73% NO= 43.27%	YES= 61.73% NO= 38.27%	YES= 51.53% NO= 48.43%

Table 7 indicates that the majority of participants consumed caffeinated beverages before the start of their shift (61.35%) throughout the season. In contrast, day shift workers were more likely than night shift workers to consume caffeine at the start of the shift (66.35% and 54.68% respectively). Fewer workers on both shifts tended to consume caffeinated beverages during their shifts (56.73%). Day shift workers were, however, still more likely to consume caffeine than their night shift counterparts (61.73% and 51.53%, respectively).

4.6.1. Work-related factors

Perceived work-pace

Workers' perceptions of the work-pace, dictated by the conveyor belts transporting the fruits, were evaluated using a Likert scale from one to five. Higher values on this scale indicate a more manageable perceived work-pace, while lower values indicate a less manageable work-pace (i.e., 1= "Not manageable", 3= "Sometimes manageable, 5= "Always manageable"). Although the pace of the conveyor was adjustable, management indicated that the pace tended to remain consistent throughout the season so that sorters were well adjusted to the pace requirement. The researcher is not certain whether management abided by the consistent prescribed pace throughout the season.

Table 8: Summary data of all participants' perceived work-pace (means; ±SD; CV). Numbers in brackets indicate the number of responses (n) obtained.

	PERCEIVED WORK-PACE
WEEK 1	3.58; ±1.12; 31.29% (33)
WEEK 2	3.55: ±0.96; 27.12% (32)
WEEK 3	3.38; ±0.98; 29.15% (32)
WEEK 4	3.38; ±0.95; 28.20% (34)
WEEK 5	3.30; ±1.21; 36.68% (33)
WEEK 6	3.21; ±1.02; 31.86% (33)

** The weeks refer to the research testing weeks rather than the consecutive calendar weeks.*

When combining the responses of all participants (Table 8), a slight decrease occurred in the perceived work-pace, indicating that, over the weeks of data collection, participants considered the pace to become less manageable, even though no significant differences were found across weeks ($p= 0.406$). Overall, participants' perceptions of work-pace were rated in the region of "sometimes manageable".

When considering the responses of the different shifts on the perceived work-pace, the day shift workers considered the pace less manageable than the night shift workers as their scores ranged 2.94 to 3.67, while the night shift scores for the work-pace ranged from 3.26 to 3.81 (Figure 9). Apart from weeks one and four, the night shift had higher values than the day shift. The differences between the shifts were, however, not statistically significant ($p= 0.197$), nor was a significant change in perceived work-pace found between the week ($p=0.516$). No interaction effect was found either ($p=0.246$).

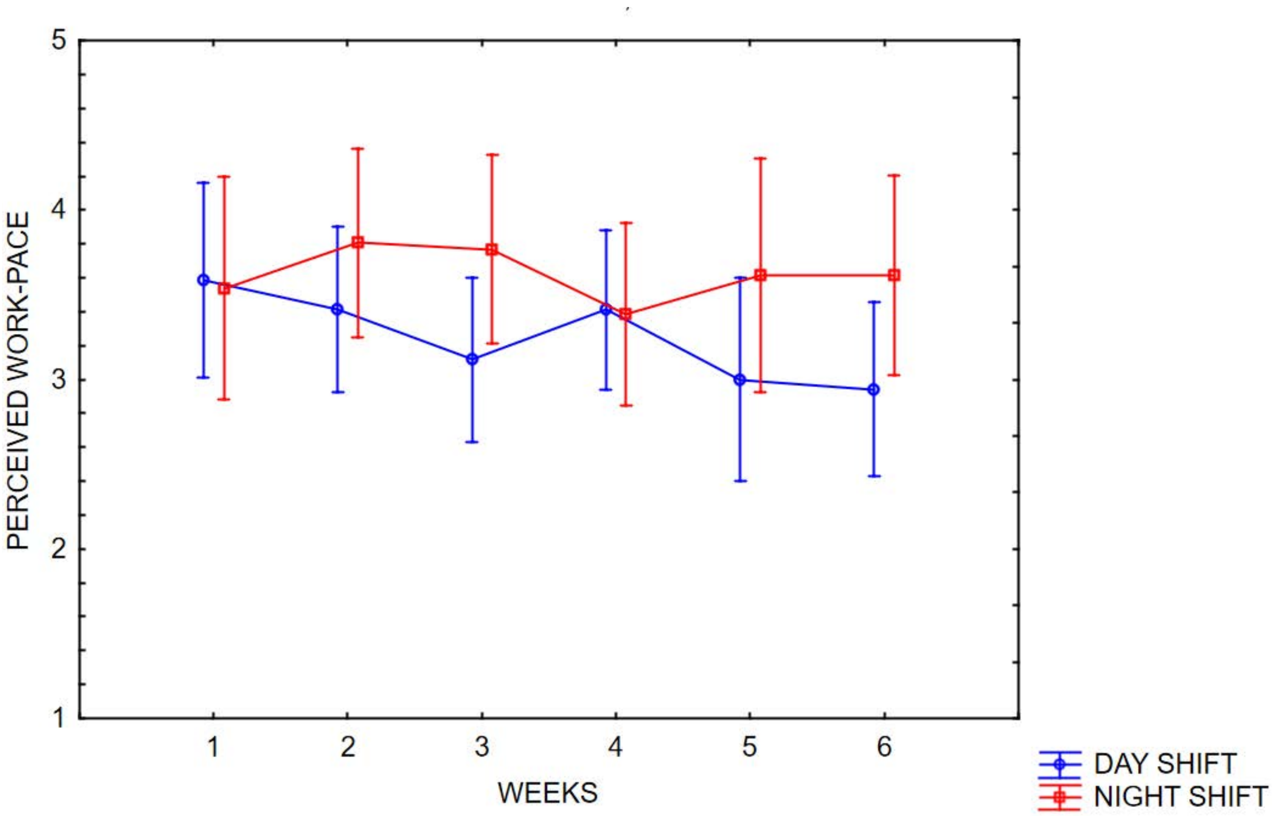

Figure 9: Average perceived work-pace scores between the different shifts.

Effects of shiftwork on lifestyle elements

Participants were evaluated if working their specific shift has negatively affected their sleep, social life, domestic life, and work performance (Figure 10). Answers were scored by circling a number from one to five. (1= "Never", 3= "Somewhat", 5= "Always"). The higher the average score, the greater the impact of shiftwork on these lifestyle elements, while a lower score indicates less of an impact of shiftwork on their lifestyle.

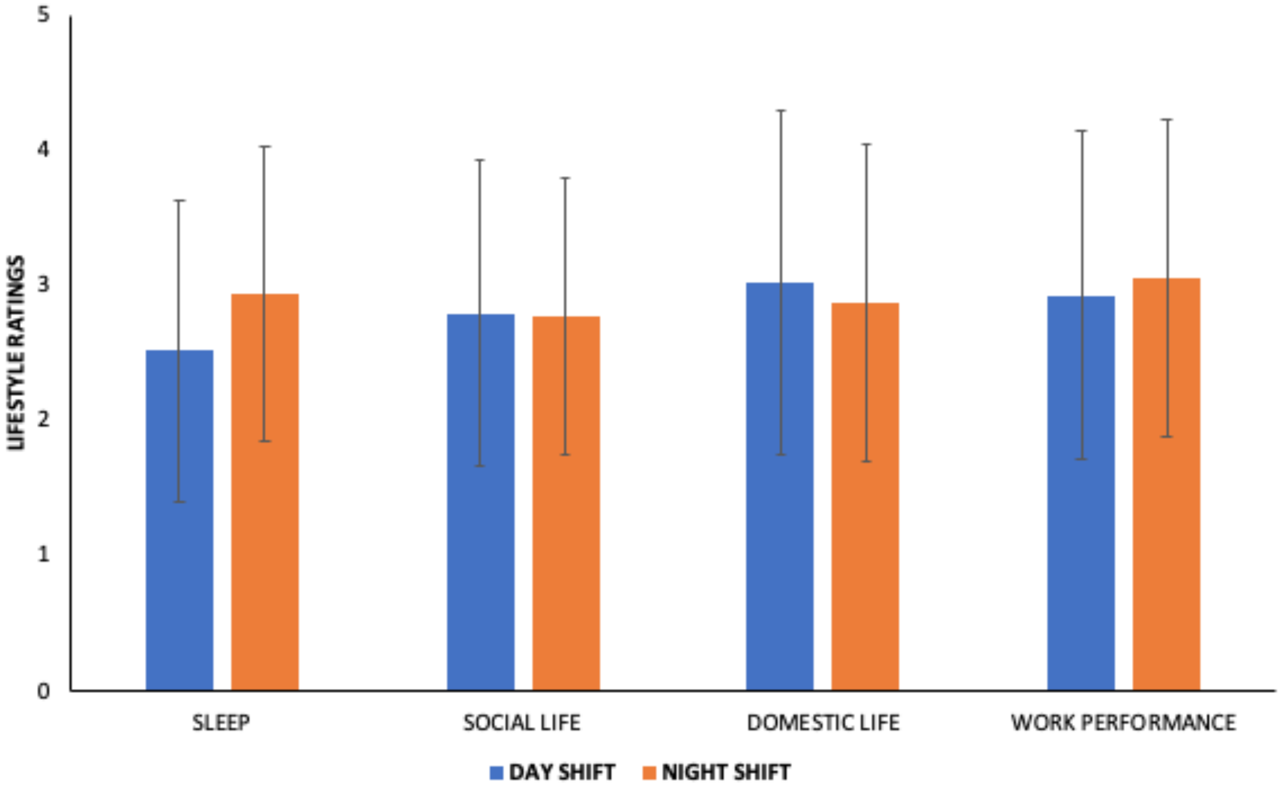

Figure 10: Ratings of the effect of shift work on the different lifestyle elements.

No significant differences were found over the weeks for the different lifestyle factors ($p= 0.378$); hence, an overall average score was produced for each lifestyle element and compared between the two shifts (Figure 10). Furthermore, it was recorded that there were no significant differences between all the lifestyle elements and the shifts. This indicates that all lifestyle elements were relatively similar between the shifts, as each element was "somewhat" affected by shiftwork over the six-week study duration. However, the sleep element provided the most noticeable difference between the two shifts, as the night shift workers had a greater perceived rating than the day shift workers. The high variability in the dataset may prove why there was no significant difference between the two shifts for all the lifestyle elements.

4.7. ENVIRONMENTAL FACTORS AND WORK OUTPUT

Data on environmental factors and work output were collected to determine whether the participants' working conditions and work demands throughout the season may contribute towards worker fatigue. Environmental recordings consisted of light, noise, and temperature measurements. In contrast, the work output recordings included the number of sorters working within the different rooms of the shift and the number of crates of fruit offloaded throughout the shift. It must be pointed out that the day shift participants were split into two different testing groups (Day shift group 1 and Day shift group 2) to allow the testing to be conducted; hence, each day shift was tested on a different day.

4.7.1. Environmental factors

All environmental recordings were taken within the packhouse at the locations where the sorters were standing at their workstations. Several recordings were taken in the different sorting rooms throughout the shift within the packhouse, as were average daily temperatures, noise levels, and lighting intensities. These recordings were averaged throughout the 6-week study duration and are displayed in Table 9. The full table of the environmental recordings can be found in Appendix C.4 while a summary of the environmental recordings can be seen in Table 9.

Table 9: Summary data of environmental recordings over the study duration (means ±SD)

	DAY SHIFT GROUP 1	DAY SHIFT GROUP 2	NIGHT SHIFT
TEMPERATURE (°C)	18.2 (±1.9)	21.4 (±4.2)	15.8 (±2.7)
NOISE (dBA)	85.1 (±0.8)	85.8 (±0.6)	85.6 (±1.9)
LIGHTING (Lux)	725.1 (±362.2)	793.1 (±50.5)	887.3 (±140.8)

On average, the night shift temperatures were lower than the temperatures obtained for the two-day shifts throughout the six-week data collection period. The highest mean temperatures were recorded during the final week of the testing period (18.1°C), while the lowest was recorded during the first week of testing (12.8°C). On average, the day shift group two experienced the warmest temperatures within the packhouse throughout the season, with a mean of 21.4°C.

Noise levels remained consistent, with limited variation across weeks and between shifts. Workers were required to wear hearing protection when they entered the packhouse and were only permitted to remove these once they left the packhouse at the end of the shift since noise levels exceeded the legal maximum limit of 85dBA.

The light recordings were gathered using the lux meter by placing it at the level of the fruit to determine the intensity of the illumination of the fruit from the sorting station lights. The average light levels were also relatively consistent between shifts, although there was considerable variation in the recordings. Day shift group one recorded the highest light intensity in week three (1295 lux); however, this intensity dropped considerably in week five (416 lux). Week one of the night shift recorded the highest light intensity (1080 lux) of its shift, but then there was a decline in light intensity for the remainder of the five weeks. Additionally, on average, the night shift recorded higher light intensities throughout the collection period compared to the day shift.

4.7.2. Work output

Work output data, as determined by the number of crates offloaded into the packhouse per shift, were recorded at the end of the shift to obtain an objective measure of the workload. Citrus crates (also known as “bulk bins” and with dimensions 1200cm (L) $\times$ 1000cm (W) $\times$ 750cm (H) mm) can carry a maximum load of 400kg (SupplyWise, 2023). The number of sorters in each room per shift was recorded to determine how this workload was distributed. The number of sorters in the different shifts per room and the number of crates offloaded each shift are presented in Appendix C.4.

The data in Table 10 was calculated by dividing the number of crates offloaded in each room by the number of sorters for the shift to allow for a comparison of workload across the shifts and over the different weeks.

Table 10: Number of crates sorted per worker in the different rooms and shifts.

	DAY SHIFT GROUP 1			DAY SHIFT GROUP 2		NIGHT SHIFT	
	ROOM 1	ROOM 2	ROOM 3	ROOM 1	ROOM 3	ROOM 1	ROOM 3
WEEK 1	-	-	-	22.76	9.67	15.36	13.76
WEEK 2	17.05	16.38	10.55	-	-	18	-
WEEK 3	50.4*	11.45	13.26	-	-	20.22	14.5
WEEK 4	12	12	11.45	19.39	17.45	17	-
WEEK 5	17.91	20.05	15.63	22.95	15.6	23.32	23.25
WEEK 6	2005	19.64	20.42	-	21	22.78	10.58

- *Indicates missing data because of shift not operating or goals for crates offloaded were not displayed on monitors.*

** Outlier in the data (possibly due to researcher error in data collection).*

Generally, the distribution of the crates sorted per sorter varied considerably throughout the season across the different weeks, shifts, and rooms. The number of crates sorted by the day shift workers throughout the season in group one ranged between 12-20. The number of crates per sorter was slightly higher for workers in group two as their range was between 16-23 (except for room thee in week one). The range of crates sorted by the night shift workers was between 14-23, which was similar to the day shift workers. Variability in the crates sorted was higher across the different weeks, as the last two weeks for all the different rooms recorded the highest work output.

4.8. CORRELATION ANALYSES

Pearson's Product-Movement Correlation analyses were conducted to determine whether individual and work-related variables may have impacted fatigue and sleepiness (Appendix C.5). The correlation tables were separated into fatigue indicator comparisons (Table 11), individual factors (Table 12), lifestyle factors affected by shiftwork (Table 13), and environmental/work output factors (Table 14).

Table 11: Correlation table of the fatigue indicators and their correlations with other fatigue indicators. Values highlighted in red indicate significant correlations.

	MFIS (PHYSICAL)	MFIS (COGNITIVE)	MFIS (PSYCHO SOCIAL)	KSS
MFIS (PHYSICAL)	1.000	0.074	0.121	0.006
MFIS (COGNITIVE)	-	1.000	0.655	0.092
MFIS (PSYCHOSOCIAL)	-	-	1.000	0.143
KSS	-	-	-	1.000

The relationship between the different fatigue indicators and sleepiness was necessary to determine if any significant correlations were associated with other adverse outcomes (Table 11). It was recorded that the KSS and the physical subscale of the MFIS had no significant correlation with any of the other fatigue indicators. This reveals that sleepiness has no relationship with any fatigue indicators, nor did physical fatigue affect any MFIS subscales and sleepiness. However, the correlation between the cognitive and psychosocial subscales was found to be of moderate strength.

Table 12: Correlation table of individual factors affecting fatigue indicators (MFIS, MFIS subscales, and KSS scores). Values highlighted in red indicate significant correlations.

	MFIS (OVERALL)	MFIS (PHYSICAL)	MFIS (COGNITIVE)	MFIS (PSYCHO SOCIAL)	KSS
AGE	0.222	0.160	0.249	0.141	0.207
NUMBER OF DEPENDENTS	0.188	0.177	0.191	0.113	0.046
EDUCATION LEVEL	-0.214	-0.189	-0.228	-0.195	-0.053
EXERCISE	-0.004	0.005	-0.040	0.001	0.094
HEALTH STATUS	-0.383	-0.407	-0.324	-0.229	0.023
YEARS EMPLOYED	0.073	-0.011	0.125	0.065	0.206
YEARS AS A SORTER	0.066	-0.001	0.103	0.051	0.259
HOURS OF SLEEP	-0.114	-0.153	-0.060	-0.168	-0.242

The correlation results in Table 12 indicate several significant correlations, which indicates these correlations were not coincidental, and that the linear correlation of this sample was sufficiently strong to apply the relationship to the population (LibreTexts Statistics, 2023). The significant correlations were however all classified as ‘weak’ correlations, except for a ‘moderate’ correlation between the physical subscale of the MFIS and the health status. Overall MFIS, the cognitive subscale, and the KSS were the only variables that positively correlated with age. However, these relationships were seen to be weak. Further positive, albeit weak, correlations were identified between the number of dependents and the overall MFIS, physical subscale, and cognitive subscale. In contrast, perceived health status negatively correlated with the overall MFIS score and physical, cognitive, and psychosocial subscales. Additionally, ratings of perceived sleepiness, as indicated by the KSS scores, shared positive, albeit weak, correlations with the number of years employed by the packhouse and the number of years as a sorter variable. Furthermore, participants’ average hours of sleep had a weak negative correlation with the psychosocial subscale and KSS scores.

Table 13: Correlation table of lifestyle elements and their correlations with fatigue indicators. Values highlighted in red indicate significant correlations.

	MFIS (OVERALL)	MFIS (PHYSICAL)	MFIS (COGNITIVE)	MFIS (PSYCHO SOCIAL)	KSS
SLEEP	0.382	0.344	0.396	0.371	0.222
SOCIAL LIFE	0.274	0.279	0.225	0.271	0.196
DOMESTIC LIFE	0.253	0.210	0.245	0.295	0.128
WORK PERFORMANCE	0.336	0.323	0.299	0.260	0.081

Regarding associations between lifestyle factors and fatigue, Table 13 indicates significant positive correlations between all the fatigue indicators and all lifestyle elements (sleep, social life, domestic life, and work performance), except for the KSS, which did not significantly correlate with 'Domestic Life' and 'Work Performance'. However, all significant correlates presented weak relationships, except for the cognitive subscale, which had a moderate positive correlation with sleep. Perceived sleepiness also correlated significantly positively, albeit weak, with sleep and social life.

Table 14: Correlation table of the environmental and work output factors affecting MFIS, MFIS sub-scales, and KSS scores. Values highlighted in red indicate significant correlations.

	MFIS (OVERALL)	MFIS (PHYSICAL)	MFIS (COGNITIVE)	MFIS (PSYCHO SOCIAL)	KSS
CRATES PER SORTER	-0.100	-0.110	-0.095	-0.107	0.031
WORK-PACE	-0.440	-0.029	-0.366	-0.234	0.001
TEMPERATURE	0.132	-0.061	0.156	-0.011	0.139
NOISE	-0.151	-0.096	-0.143	-0.037	0.037
LIGHTING	-0.127	0.228	-0.143	-0.010	0.078

No significant associations were identified for the number of crates sorted per worker, temperature, and noise. Work-pace yielded significant negative correlations, albeit weak, with the cognitive and psychosocial subscales. However, there proved to be a moderate correlation with the relationship between work-pace and the overall MFIS scores. Lighting showed a significant but weakly positive correlation with the physical subscale of the MFIS.

CHAPTER 5: DISCUSSION

5.1. FATIGUE PREVALENCE

Over the six weeks of data collection, it was identified that the average overall MFIS score for the study duration for all participants was 39.35 which is greater than the predetermined MFIS fatigue threshold. Studies by Kos et al. (2005) and Téllez et al. (2005) that used the MFIS indicated that an overall MFIS score of 38 was considered the threshold of fatigue. Any score equal to or greater than that would classify a person as 'fatigued', while scores of less than 38 would be classified as 'non-fatigued'. The average MFIS scores for all the participants exceeded this fatigue threshold after week three until the end of the study. However, when analysing participants individually, there was considerable variability in the study; 21 participants (60%) exceeded the fatigue threshold score, while the remaining 40% did not.

It was expected that participants would experience a gradual increase in fatigue scores throughout the season, as Techera et al. (2016) pointed out when an individual is exposed to various potential stressors for an extended period that may induce fatigue symptoms. Fatigue consequences were anticipated to be exacerbated through continuous exposure to various factors throughout the harvesting season; however, findings from the current study showed no significant differences in the MFIS scores over the weeks ($p = 0.122$). A possible justification for data having no fluctuation over weeks may be that participants have adequately mastered the training effect of the work demands throughout a season. On average, participants had worked in the citrus sorting industry for 9.3 (±8.57) years, thus indicating that participants had acquired abundant sorting experience and could anticipate the sorting demands. However, the average participant was still exposed to fatigue symptoms for over half of the season.

The KSS scores, on the other hand, revealed that, on average, participants did not exceed the threshold for excessive sleepiness in any of the weeks. Geiger Brown et al. (2014) claimed that a KSS score of seven or greater is considered extremely sleepy. When viewing the KSS results independently, only eight participants (23%) recorded scores of seven or greater, demonstrating that although most of the sorters fell below the sleepiness threshold, a few participants perceived to experience excessive sleepiness throughout the season. Additionally, 13 participants (37%) indicated they displayed some signs of sleepiness symptoms, which impacted them throughout the season. It was expected that participants in the study would have a moderate increase in levels of perceived sleepiness over the season, as even small amounts of sleep loss are known to produce measurable increases in sleepiness and fatigue (Dawson et al., 2011). However, when considering the fluctuation of perceived sleepiness over the weeks, participants recorded the highest degree of sleepiness during the last week of assessment (5.33). Nonetheless, no significant differences were found for sleepiness over the weeks of the study duration (p= 0.885), indicating that levels of sleepiness were relatively consistent over time.

It was necessary to ensure that sleepiness was acknowledged within the current study as it may have contributed considerably to determining fatigue levels. Sleepiness is regarded as one of the most significant indicators of occupational fatigue in workers (Dawson et al., 2011). However, the results of the current study conflict with Dawson et al. (2011), as sleepiness did not have a significant correlation with overall fatigue or any fatigue subscales (Table 12). A possible explanation may be that excessive sleepiness and fatigue are two distinct concepts with overlapping features or symptoms; thus, the terms are often used interchangeably (Pigeon et al., 2003; Shen et al., 2006). Both phenomena are influenced concurrently as the lack of sleep contributes towards employee fatigue, while increased levels of fatigue promote sleepiness (Williamson et al., 2011; Yumang-Ross & Burns, 2014). Therefore, individuals unaware of the differences between fatigue and excessive sleepiness frequently use the terms simultaneously and will regard themselves as ‘tired’ (Shen et al., 2006).

5.1.1. Types of Fatigue

Participants throughout the harvesting season identified physical fatigue as the most prominent type of fatigue. The relative MFIS scores for the physical subscale of all the participants were consistently higher for every week of the data collection period compared to the cognitive and psychosocial subscales, even though there was no statistically significant difference between the subscales. Furthermore, the physical subscale was the only subscale in the study to record a significant difference over time (p= 0.033), with the difference between weeks one and five. This suggests that all participants experienced a considerable increase in the perception of physical fatigue, which may support the researcher’s expectation of cumulative fatigue over time. When analysing the questions assessed in the MFIS independently, it was recognised that questions 21 and 13 (physical fatigue-related) were the second and third-highest overall scores, respectively. These questions were "*I have needed to rest more often or for longer periods after work*" and "*My muscles have felt weak*". These perceived issues may originate from the static standing posture adopted by the citrus sorters with a flexed neck position while performing frequent upper extremity motions of the hand/wrist, forearm, elbow, and shoulders. These positions were maintained throughout the shift, where only minimal postural changes would allow the muscles little time to recover between static muscle contractions. Occupational work demands that require prolonged static postures may develop functional impairments of muscle, predominantly in the shoulder and neck region, known as myalgias (Kilbom et al., 1996). These complaints have been acknowledged in research, as a study by Lawan et al. (2018) that explored orange handling operations in Yanlemo, Nigeria, concluded that the most common discomfort experienced by workers was lower back pain. Furthermore, a study by Simcox et al. (2001) on self-reported discomfort of apple sorters found that the highest discomfort ratings were in the upper/lower back and the shoulders. When workers are exposed to tasks requiring repetitive exertion and high work demand, discomfort in workers' muscles results in physical fatigue, and the risk of musculoskeletal disorders increases (Kilbom et al., 1996).

Although the psychosocial subscale had the lowest absolute scores across all weeks in the MFIS, once relativised, the psychosocial scores were similar to that of the physical subscale. Furthermore, the psychosocial subscale of the MFIS had the greatest variance across all weeks compared with the other subscales, which may account for the lack of significant differences across the different scales and weeks. The average psychosocial score for all the participants across the measurement weeks was 46.32%, indicating moderate levels of psychosocial fatigue. Carayon & Smith (2000) describe psychosocial work factors as employees' perceived characteristics of the work environment and non-work factors that have emotional implications, which can result in stress and strain. These questions that the MFIS consisted of were, "*I have been less motivated to participate in social activities*" (Question 8) and "*I have been limited in my ability to do things away from home*" (Question 9). The social life of all the participants was, on average, perceived to be "somewhat" affected by the demands of their shiftwork (Figure 10). These perceptions may be influenced by the number of work hours participants have, as day shift workers are prescribed 10-hour shifts, while night shift workers have 12-hour shifts. Additionally, 33 participants (94%) stated that they were "sometimes" required to assist in overtime work on weekends, thus having limited time off-duty to socialise. Behavioural actions such as socialising outside the workplace are known to alleviate work stressors and aid the recovery process from symptoms of fatigue (Aaronson et al., 2003; Yumang-Ross & Burns, 2014).

Cognitive fatigue displayed marginally lower MFIS scores across the harvesting season compared to the other subscales. Furthermore, cognitive fatigue levels recorded no significant difference over time (p= 0.180), indicating that participants' perception of cognitive fatigue was relatively consistent over the season. This trend of cognitive fatigue was not expected, as Williamson et al. (2011) stated that fast-paced, monotonous, and repetitive tasks over time resulted in workers developing cognitive fatigue, which may disrupt the work system's productivity. These characteristics correspond to a citrus sorter's task requirements; thus, it was speculated that sorters in the citrus industry might be particularly exposed to an accumulation of factors that may produce cognitive fatigue and provoke negative consequences. A study by Boksem et al. (2005) examined the effects of cognitive fatigue on a visual attention task that was performed continuously for three hours without rest. It was concluded that subjects developed difficulties staying alert and sustaining attention over time so that the task could be performed at an acceptable level. Additionally, the study concluded that increased cognitive fatigue induced a decrement in performance, as errors in false alarms and missed targets increased during the 3-hour task (Boksem et al., 2005). Although this conclusion of their study was short-term, it has been noted that continuous acute cognitive fatigue symptoms can impact individuals' behavioural and emotional responses to induce chronic cognitive fatigue (Shen et al., 2019). Furthermore, the current study examined that Question 1 ("*I have been less alert*") of the MFIS was the highest recorded score on average amongst all the participants over the season. This consensus of being 'less alert' has been acknowledged as one of many consequences of cognitive fatigue and sleepiness (Caldwell et al., 2019; Neu et al., 2011). Possible explanations for cognitive fatigue levels being reasonably constant throughout the harvesting season could be an adaptation to the demands of the sorting task. On average, participants worked as sorters for 9.3 (±8.57) years, indicating they have considerable experience with the task demands. This could be why there was no relationship between the number of years as a sorter and fatigue onsets. The current study did not measure the accuracy of the sorter's performance; thus, it is difficult to judge whether cognitive fatigue affected the quality of the sorting performance. Furthermore, it can be established from this study that cognitive fatigue was not a significant outcome for citrus sorters throughout the season.

Overall, when comparing the variation of the subscales over time, there was a significant difference (p= 0.003) between weeks two and three. Week three produced the highest maximal MFIS percentages for the physical (55.49%), cognitive (46.25%), and psychosocial (50.00%) subscales throughout the entire data collection period. Furthermore, there was no significant variation in fatigue subscale maximal percentages (p= 0.528), from which it can be concluded that all fatigue components affected the participants similarly.

5.1.2. Effect of shiftwork

It was speculated that workers on the night shift would perceive higher levels of fatigue and sleepiness due to their altered 'natural' sleep behaviours and extended work hours. Additionally, women working the night shift are tasked with stressful living conditions as they are responsible for domestic duties at home and still require adequate recovery from the work shift (Costa, 1996). However, it was found that the day shift workers perceived higher fatigue levels as their overall MFIS scores were greater than those of the night shift workers across all weeks of the harvesting season. Of the day shift participants, 78.6% had an overall MFIS greater than the fatigue threshold, compared to only 55.6% of the night shift workers. Despite this, there was still no significant difference between the two shifts (p= 0.209), nor was there a significant difference in the fatigue ratings over the weeks of the data collection (p= 0.112). These findings correspond with a study by Åkerstedt et al. (2002), who analysed the relationship between shiftwork, overtime, and high workloads on the effects of fatigue and sleepiness on a large sample in Sweden. It was concluded by Åkerstedt et al. (2002) that shiftwork had no significant correlation with fatigue; however, the day-orientated workers were more impacted. A further conclusion of this study was those night shift workers might consider 'sleepiness' as a better description of their situation than perceptions of fatigue (Åkerstedt et al., 2002). This may be the case for why night shift participants in the current study had perceived lower fatigue levels than day shift workers.

When assessing the average levels of sleepiness, it was found that night shift participants' level of sleepiness remained higher than the day shift workers' across the season. It was expected that night shift workers would obtain a greater sleepiness score as this corresponds with previous studies (Caldwell et al., 2019; Williamson et al., 2011), which argued that the day shift participants received the most sleep, with an average of eight hours per week. This was in line with the recommended number of sleep hours (7-8 hours) necessary for efficient human functioning by Lerman et al. (2012). Conversely, the night shift workers failed to attain the recommended hours of sleep set out by Lerman et al. (2012), as they only recorded an average of 6:44 hours. Additionally, it was found that participants who acquired higher KSS scores had a significant correlation with fewer hours of sleep ($r= -0.238$), indicating that the number of hours of sleep affected increased sleepiness. These results corresponded with the night shift workers' perceptions as they indicated that sleep was the lifestyle element most affected because of their shiftwork and exhibited higher scores than the day shift workers. However, it was not expected that the sleepiness data would have no statistical difference between the shifts ($p= 0.489$) nor over time ($p= 0.883$). Rotenberg et al. (2011) stated that working frequent night shifts would expose workers to an accumulation of sleep loss, as drowsiness levels would increase and ultimately leading to long-term exhaustion. However, it was found that adjustments to the individual's biological clock through continued exposure to night shift working hours may help workers minimise sleepiness and fatigue symptoms (Ahasan et al., 2001). Tolerance to shift cycles has been defined as the adjustments to night shift workers' circadian phase, and it is estimated that night shift workers can adapt after a week (Ahasan et al., 2001). The packhouse had employed participants for 12.4 (±7.97) years on average; thus, possible adaptations to the work system, work procedures, and night shift may have occurred for participants not to experience increased sleepiness over time.

5.2. CONTEXTUAL INFLUENCES OF FATIGUE

The fatigue indicators of this study show that citrus sorters are vulnerable to fatigue and reported that fatigue symptoms affected all three fatigue domains. This may indicate that different causal factors contributed to the prevalence of worker fatigue. To understand the causal factors of occupational fatigue, it is essential to understand work- and non-work-related influences and to have a holistic appreciation of the employees' demographic characteristics and their private situation. As acknowledged in the occupational fatigue model by Kant et al. (2003), there are multiple links and relationships between the different work system elements that may cause or contribute to fatigue in the working population. This provides difficulties in identifying a particular causal factor contributing to the citrus sorters' overall fatigue. It is, therefore, necessary to acknowledge the many contributing factors from the work situation, the individual, and their private situation, as recognised in Kant et al.'s (2003) model of occupational fatigue.

5.2.1. Work situation

For many workers, the workplace is their primary cause of fatigue (Williamson & Friswell, 2013). Many factors from different elements within the work situation can contribute towards worker fatigue, as seen in the occupational fatigue model by Kant et al. (2003). However, it may not be possible to acknowledge or remove all negative aspects that promote fatigue from a working system (Murphy et al., 2014).

Conditions of employment

Shiftwork affected workers' lifestyle factors and fatigue symptoms in the current study. Participants who perceived their sleep schedule to be more affected by shiftwork also scored higher on the fatigue indicators and sleepiness ($r= 0.222$). It has been well established that sleep is the primary function that gets altered due to night shift demands as an alteration in sleep quality and a reduction in sleep duration is obtained (Costa, 1996). However, Åkerstedt et al. (2014) indicated that adaptation to the demands placed on the circadian rhythm occurs after working several night shifts in a row. Studies by Shen & Dicker (2008) and Han et al. (2014) found that workers who had fixed work schedules (working either day or night shift) were able to adapt to their work schedules and found successful strategies to ensure optimal recovery for symptoms of fatigue. Thus, for participants in the study who worked on a fixed shift rotation, adaptation to their shift schedule may account for why shiftwork was only a minor contributor to fatigue and sleepiness.

Shiftwork has been documented to place considerable stress on family relationships, particularly on night shift workers, where a proportion of ‘break-ups’ of families amongst the workers in the organisation were recorded by Shen & Dicker (2008). This could be attributed to the spouses working different shifts and thus not being able to spend enough time together and with family. However, only four participants (11%) in the current study were married; thus, shiftwork affecting the relationship between spouses may only impact a minority of the participants. Furthermore, Shen & Dicker (2008) stated that shiftwork could hinder the social life of workers, which may intensify the symptoms of psychosocial stress and fatigue. Participants of both day and night shifts in the current study perceived that their domestic and social life was “somewhat” affected by their shiftwork (Figure 10). Moreover, participants whose domestic and social lives were greatly affected by shiftwork were found to have higher fatigue ratings in all the subscales, although these correlations were weak.

Work conditions

Light intensity is a critical component for an effective sorting operation when it comes to the physical environment in which the sorting task happens. It impacts the sorters’ visual perception and ability to detect defective fruits and reduces the strain on the sorters’ eyes, particularly night shift workers (Bollen & Prussia, 2014). There are conflicting opinions on whether the results of the current study correspond with the literature, as it is recommended that light intensities of 1000 lux or greater are necessary for inspection tasks such as the ones at the citrus sorting tables (Bollen & Prussia, 2014). In contrast, Sanders and McCormick (1993) pointed out that the recommended illumination levels for visual tasks of medium contrast or small-size items should be between 500-1000 lux. It was found that the average illumination of the night shift tables (887.3 lux) over the season was brighter than the two-day shift groups (725.1 and 793.1 lux). Physical fatigue was the only fatigue variable to be influenced by lighting ($r = 0.228$), which implies that light intensity had a significant, albeit weak, impact on fatigue.

Internal temperatures at the sorting lines were relatively consistent with the harvesting season. The night shift recorded the lowest average temperatures (15.8°C), which was expected, while the two-day shift groups recorded higher temperatures (18.2°C and 21.4°C respectively). These average temperature measurements are well below the upper threshold limit (28°C) for extreme heat, however, were marginally below the lower threshold limit (19°C) for cold temperatures (ANSI/ASHRAE, 2004). The ASHRAE Standard 55-2017 prescribes the thermal comfort range for occupational workers to be between 19°C to 28°C (ANSI/ASHRAE, 2004). Temperatures above or below this comfort range are claimed to reduce levels of alertness while performing vigilance and cognitive tasks and can result in physical discomfort or cognitive fatigue (Lerman et al., 2012; Mahdavi et al., 2020). Throughout the study, the warmest temperature recorded in the packhouse was week six (25.5°C) for group two of the day shift, while the coldest temperature recorded was in the first week during the night shift (12.8°C). In the current study, heat may not validate as an environmental issue. However, cold temperatures may have a possible influence on night shift workers as their average temperatures throughout the season were below the ANSI/ASHRAE (2004) comfort threshold, even though no significant correlations were found between temperature, fatigue, and sleepiness variables. This suggests that temperature had no significant contribution towards the causation of fatigue among citrus workers.

Finally, the average noise levels throughout the season for the day shift group one (85.1 dBA), day shift group two (85.8 dBA), and night shift (85.6 dBA) were the most consistent of all the environmental recordings in the entire study. Most studies that have attempted to understand the effects of noise levels on individual performance have been primarily conducted within a laboratory setting (Lerman et al., 2012). However, subjective feelings of unpleasantness and complaints of fatigue have been reported when individuals are exposed to prolonged periods of high noise levels (Lerman et al., 2012). A study by Kołodziej and Ligarski (2017) found that line production workers labelled high noise levels as the second most common element within the workplace to impact their work productivity. Despite noise levels having no significant relationship between fatigue and sleepiness in the current study, the noise levels remained consistent throughout the testing weeks. This may have potentially contributed towards a constant fatigue baseline level for the employees exposed to the persistent noise levels.

Work content

The workstation of the citrus sorters required prolonged standing postures and a flexed trunk for most of their shift due to the nature of the citrus inspection and handling task. Studies have suggested that prolonged standing is one of the leading causes of physical fatigue within industrial work as it initiates discomfort in workers' lower extremities and lower spine while maintaining a static posture (Halim et al., 2012; Waters & Dick, 2015). Additionally, it has been alleged that visual demands and mental load can generate muscle tension which adds to the postural load (Kilbom et al., 1996) and which is in the task demands of citrus sorters. The standing period for the participants varied as it was estimated that the day shift workers stood for about 8:45 hours, while the night shift workers stood for an estimated 10:40 hours, an extensive period of static standing. Therefore, prolonged standing may contribute to workers' cumulative physical fatigue over the season. However, rest breaks allow time-on-task pressures to be eased during occupational work. It was concluded in a study by Tucker et al. (2006) that although the benefits of occupational rest breaks may be short-lived, they are an effective method of mitigating the risk of accumulating fatigue. Participants in the current study were appointed with three rest intervals during their shift, amounting to about 1:20 hours. Studies have found that shorter and more frequent rest breaks benefit workers' productivity and reduce the risk of injuries compared to one long mid-shift rest break (Caldwell et al., 2019; Lerman et al., 2012).

Furthermore, higher work-pace has been associated with greater shoulder muscle activity, muscular fatigue, and increased perceived discomfort (Bosch et al., 2011). Translation speed is the velocity at which the fruit passes the sorter on the conveyor belt (Bollen & Prussia, 2014). Day shift workers' responses to the perceived work-pace of the translation speed were "less manageable" for all weeks (except week one) compared to those of the night shift workers. These perceptions may explain why day shift workers recorded higher levels of overall fatigue and physical fatigue than night shift workers. Additionally, a work-pace perceived to be "less manageable" significantly impacted cognitive (r= -0.366) and psychosocial (r= -0.234) fatigue ratings (Table 14). These relationships may be weak and appear to be a minor contribution towards fatigued development. However, work-pace had a moderate relationship with overall fatigue (r= -0.440), indicating that the less manageable participants perceived their work-pace, the greater their fatigue levels.

Work output data varied greatly throughout the harvesting season as the citrus fruit intake for the packhouse depended on the fruit's cultivar, quality, and point within the season. Table 10 of the work output presents numerous missing data points and outliers due to different work-related incidents (e.g., shifts not working, monitors offline, rolling blackouts aka 'load-shedding', researcher error), thus making it difficult to analyse the work distribution throughout the season. Additionally, there was no significant relationship between the number of crates sorted per sorter influencing fatigue or sleepiness variables.

5.2.2. Individual factors

Dawson et al. (2011) stated that susceptibility to fatigue development varies significantly between individuals and that individual characteristics play a significant role in a person's perception of fatigue symptoms. Since no previous studies had been conducted on citrus workers, particularly within the Sundays River Valley context, it was necessary to acknowledge the participants' demographic characteristics and backgrounds. All participants in the study were female with a mean age of 38 years, where the majority identified as being of "Black/African" ethnicity and speaking isiXhosa as a home language. These results resemble the 2022 South African population estimates published by StatsSA (2022), which indicated that of the female population, 81% are classified as "Black African".

In terms of fatigue responses, it was expected that the older aged workers would have perceived higher levels of fatigue, even though the evidence of age correlating with fatigue is mixed in research (Winwood et al., 2006). This assumption proved to be appropriate as it was found that the older the workers perceived greater overall fatigue (r= 0.222), cognitive fatigue (r= 0.249), and high sleepiness levels (r= 0.207). Literature states that the strength of muscle fibres diminishes with age and that standard ageing triggers diminished cognitive functioning, thus being the possible reason why fatigue is higher amongst elderly workers (Finsterer & Mahjoub, 2014; Gilsoul et al., 2019). However, the relationship of age with increased levels of fatigue and sleepiness is considered weak; therefore, the influence of age may only be a minor contributor.

Perceived health status was reported to be 'good' by 20 participants (57%), despite almost a third of participants (34%) indicating that they suffered from a chronic illness.

According to the South African Demographic and Health Survey (SADHS, 2016), 23% of South African women are diagnosed with hypertension, while 23% are HIV positive. These statistics illustrate that chronic illnesses, especially among women, are rife. Although fatigue is present in healthy individuals, chronic illnesses promote greater severity and duration of fatigue symptoms, impacting the individual's quality of life more considerably (Jorgensen, 2008). The sample's perceived health status corresponds to the self-reported health status gathered by the SADHS (2016), as 39% of women in South Africa reported their health to be 'good' and 34% to be 'average'. Aaronson et al. (2003) claimed that healthy subjects who participated in regular exercise, nutrition, and good sleep found it easier to alleviate fatigue symptoms. Participants in the current study who perceived to have greater levels of health also had significantly lower levels of physical, cognitive, and psychosocial fatigue. Even though this relationship was weak, it illustrates that good health positively affects fatigue alleviation.

One contributor to poor health in South Africa is the use of tobacco and alcohol, as it generates an increased risk for cardiovascular diseases and cancer and can hinder recovery from fatigue (Samaha et al., 2007). Alcohol is a depressant that slows the nervous system and disturbs sleep behaviours; therefore, alcohol consumption has been accredited with reductions in sleep quality and extended periods of wakefulness (Dawson et al., 2011; Theron & Van Heerden, 2011). Nicotine also stimulates the nervous system and should be avoided before bed, as cigarette smokers are more likely to report sleeping problems than non-smokers (Caldwell et al., 2019). Of the participants in this study, only 29% claimed that they occasionally partook in using substances (smoking, drinking, or recreational drugs). It, however, cannot be concluded with certainty whether and to what extent, smoking or alcohol consumption contributed towards fatigue in this study as it was not documented how often these substances were used and in what quantities. These data only depict how many participants' general health may be affected by these activities, thus potentially making them more susceptible to fatigue.

The employment status of women in the Eastern Cape province, as published by SADHS (2016), highlighted that only 32.2% of women surveyed were currently employed, and more than 63% of women had no form of employment 12 months prior to the survey. With the majority of the participants (85%) in this study not completing high school and only five participants having completed high school (15%), it would be difficult for participants to attain a more profitable occupation. Participants resemble the population of the SRV as only 15.2% of residents in the area had completed their matric (final year of high school) (StatsSA, 2011). Therefore, with the scarcity of job opportunities, particularly within the SRV's semi-rural area, and the participants' low qualifications, once workers had found employment, they would ensure to retain the occupation for many years to ensure their economic stability. This explains why the average duration employed by the packhouse was relatively high (12.4 years). Additionally, participants who held lower levels of education were found to be more significantly affected by overall (r= -0.214), physical (r= -0.189), cognitive (r= -0.228), and psychosocial fatigue (r= -0.195). These results correspond with the study by Engberg et al. (2017), who found that highly educated individuals perceived lower fatigue levels.

Coping mechanisms refer to an individual's behavioural efforts to manage internal and external stresses that contribute to fatigue levels (Samaha et al., 2007). Results from a study by Lu et al. (2017) revealed that the top short-term coping method for fatigue by 451 manufacturing workers in the United States was the consumption of caffeinated drinks (51.5%). Although caffeine consumption is a secondary method for fatigue alleviation, it has been acknowledged that caffeine is one of the few substances that allow individuals to cope with sleepiness and combat fatigue in the workplace (Geiger Brown et al., 2014; Lerman et al., 2012). In the current study, participants' caffeine consumption before and during the shift was assessed, and it was discovered that on average more day-shift participants (66%) claimed to drink caffeinated beverages more than the night-shift participants (54%) over the study duration. Additionally, the day shift workers claimed to have consumed caffeinated beverages more (62%) during the shift than compared to the night shift workers (52%) on average over the study duration. However, caffeine consumption within six hours of sleep can contribute to sleep loss (Theron & Van Heerden, 2011). This could be why night shift workers did not consume as much caffeine during their shift compared to day shift workers, as it is assumed that they would sleep after completing their shift. Additionally, this regular caffeine consumption may be a minor contribution to the day shift workers' lower perceptions of sleepiness.

5.2.3. Private situation

The private context of each worker plays a pivotal role towards the contribution of fatigue symptoms or assisting in alleviating consequences of fatigue. Individual daily routines and activities, such as caregiving, commuting to work, exercise, or social life activities, involve different levels of stress and require different levels of adequate recovery (Dawson et al., 2011; Kilbom et al., 1996).

Black South African family structures often mean that females take on the ‘traditional’ role as breadwinners and caregivers because many black South African children live with absent fathers (Bosch et al., 2012). In 2009, only 30% of black South African children under 15 had fathers in their households (Bosch et al., 2012). This means that females, particularly in South Africa, have different social and family responsibilities at home than their male counterparts, which may negatively impact their recovery periods and feedback on their work performance. The participants in the study stated that, on average, they had two (±1.54) children and one (±1.53) elderly living at home with them. Furthermore, most participants (89%) were single or widowed, which means they were entirely responsible for the dependents within the family and would be likely to tackle more domestic duties than those workers who are married or living with a partner. Domestic care and caregiving are known psychosocial factors that affect an individual’s physical and mental health (Thomas et al., 2020). Additionally, these single or widowed participants would be responsible as the primary financial provider for their families, which may potentially develop further psychosocial stressors. However, the psychosocial subscale was the only subscale of the MFIS that was not influenced by the number of dependents, probably due to considerable variability in the participants’ ratings. The number of dependents had a minor contribution towards the influence of physical ($r= 0.177$), cognitive ($r= 0.191$), and overall fatigue ($r= 0.188$).

Commuting to and from work has been viewed as a contributing factor towards worker fatigue, as the form of transportation may affect an individual’s physical and social pressures (Satterfield & Van Dongen, 2013). Additionally, Satterfield and Van Dongen (2013) pointed out that commuting times impact the opportunity to acquire adequate sleep quality and periods of wakefulness, particularly if employees are walking or have longer travelling distances. According to StatsSA (2022), 17.4 million South Africans walk to work daily, whereas 10.7 million residents must use public transport, such as so-called ‘taxis’. However, workers in the current study were fortunate that the company provided transport to and from work, and all participants indicated to benefit from this initiative. This would alleviate any social and physical stressors if employees were required to find an alternative method of transport, such as public, private, or physical methods.

Physical exercise has proven to provide many benefits, such as boosting energy levels, improving health and well-being, and improving sleep quality (Theron & Van Heerden, 2011). Of the participants in the study, only 13 (38%) stated that they exercised once a week or more, while the rest stated they either exercised once a month (29%) or never (46%). Many black South African women are faced with contextual factors that restrict them from engaging in physical exercise (Walter & du Rosa, 2011). These factors include a lack of family support, access to facilities, cultural barriers, safety concerns, domestic responsibilities, and job responsibilities (Walter & du Rosa, 2011). A possible reason for most participants not wanting to engage in physical exercise are the long working hours spent within the packhouse and possibly prioritising the non-working times to recover from the workday. There was, however, no significant statistical correlation between exercise and the fatigue or sleepiness indicators, thus demonstrating that exercise was not a contributor to fatigue nor a mechanism to alleviate fatigue.

In summary, participants experienced fatigue throughout the season; however, there was no significant effect on fatigue between shifts or over time. This was not expected, as it was anticipated that overall fatigue responses would increase over time. This expectation was formulated based on literature, the nature of the job, and the contextual backgrounds and circumstances of the participants. However, physical fatigue accumulated significantly over time, as there was a difference between responses in weeks one and five. There was not a single factor that stood out to significantly influence fatigue or sleepiness; instead, it was found that multiple factors provided minor contributions to worker fatigue. This corresponds with fatigue literature, as multiple causal factors may simultaneously collaborate to impact the individual and stimulate negative symptoms of fatigue (Aaronson et al., 1999; Williamson et al., 2011; Winwood et al., 2005).

CHAPTER 6: CONCLUSION, LIMITATIONS, AND RECOMMENDATIONS

6.1. OVERVIEW OF THE STUDY

This study investigated the prevalence of fatigue among citrus sorters in a citrus packhouse in the Sundays River Valley of the Eastern Cape in South Africa throughout a harvesting season. The citrus sorting process requires accurate attention to detail to ensure that all nonconforming fruits are discarded from the packing line. It was anticipated that the citrus sorters might experience symptoms of fatigue, given their exposure to various work-related and private situations. These fatigue symptoms may impact their sorting performance if not recognised and mitigated. Since no previous research had been conducted on citrus sorters in South Africa, it was not known whether fatigue was an issue among these workers and to what extent it may have impacted worker well-being or sorting performance. Therefore, the objectives of this study were to determine if citrus sorters experienced fatigue and, if so, what type of fatigue was most prevalent. Further monitoring of fatigue levels throughout a citrus season was necessary to analyse if any fatigue fluctuations occurred. Additionally, since some packhouses in the citrus industry employ shift workers, a comparison of fatigue levels between day and night shift workers was conducted to determine if there were any disparities in fatigue between the two shifts. Lastly, it was deemed essential to identify any associations that may contribute towards fatigue. Recognising potential causal factors and identifying possible worker fatigue would be an essential first step for implementing a fatigue management process to improve worker well-being and aid packhouse systems' work quality and quantity.

6.2. SUMMARY OF METHODS AND PROCEDURES

This study adopted a repeated measures approach for a cohort research sample. Once consent had been obtained from all stakeholders, participants were asked to complete various questionnaires and surveys that were provided in English and isiXhosa. Each measurement of fatigue can only partially capture the phenomenon's complexity and holistic nature, therefore requiring different assessment tools. The study used a two-part protocol: Part one consisted of a once-off questionnaire relating to demographic questions and their working context. The second part was a repeated assessment that consisted of questions regarding the work context, two fatigue surveys (MFIS and KSS), and environmental and work-output recordings. This second part of the method was repeated every three weeks throughout the harvesting season. Various statistical analyses (descriptive statistics, Shapiro-Wilks test for normality, General Linear Models, Tukey post-hoc tests, and Pearson's-Product Movement Correlation Coefficient Analysis) were used to address the research objectives.

6.3. SUMMARY OF FINDINGS

One packhouse consented to participate in the study, where the participant's sample comprised 35 citrus sorters (19 day-shift and 16 night-shift workers). All the participants were female, of which the majority (94%) classified themselves as "Black/African". The average age (38 years), work experience as a sorter (9.3 years), level of education (grade 11), and the number of dependents (three) were individual characteristics that were considered potential influences on the onset of fatigue.

The average MFIS score for all the participants was 39.35 across the study's duration, which exceeded the MFIS fatigue threshold of 38, indicating that participants were experiencing symptoms of fatigue. Fatigue ratings for all the participants exceeded this fatigue threshold for all the weeks of data collection, except for weeks one and two. Overall, 21 participants (60%) had an average MFIS score that exceeded this fatigue threshold. On the contrary, only eight participants (23%) exceeded the excessive sleepiness threshold of the KSS, which was seven. It was noted that the highest sleepiness ratings for all participants were recorded in the final week of the assessment, which may be influenced by the excessive exposure to work-related and private situation elements over time. However, there were no significant differences in overall MFIS and KSS scores over the six weeks of data collection, indicating no considerable fluctuation over time for general fatigue and sleepiness.

The relativised scores of the different MFIS subscales revealed that the participant's cognitive and psychosocial subscale scores were relatively consistent, as there was no significant variation over time. Conversely, the physical subscale exhibited the highest average scores across all weeks compared to the cognitive and psychosocial subscales, despite no statistically significant difference in fatigue. The high ratings of physical fatigue could be attributable to the long time-on-task periods, the prolonged standing, and the highly repetitive sorting task. Additionally, there was a significant increase over the weeks for the physical subscale. A Tukey post-hoc analysis identified that the difference lay between weeks one and five, suggesting an accumulation of fatigue. This significant accumulation of physical fatigue scores over time partially confirms the researcher's speculation that fatigue would increase throughout the harvesting season, albeit only for one subscale.

When comparing fatigue scores between shifts, it was concluded that the day shift workers had greater fatigue levels, albeit not statistically significant, than the night shift workers, as sorters in the day shift reported moderately higher MFIS scores over the entire harvesting season. The day shift workers' average MFIS score exceeded the fatigue threshold for all weeks of the harvesting season, which may be attributable to the perceived work-pace. The work-pace may have contributed to the higher fatigue levels for the day shift workers as they perceived the work-pace to be less manageable than the night shift workers throughout the majority of the study duration. On the other hand, the night shift workers only exceeded the fatigue threshold for the last two weeks of the season. This increased level of fatigue for the night shift may be attributable to the waking times, as they reported waking up two hours earlier for the last two weeks of the study than compared to earlier weeks.

When assessing the perceived sleepiness levels of citrus sorters across the season, the night shift workers had higher levels of sleepiness than the day shift workers. Fewer hours of sleep may have contributed to higher perceived levels of sleepiness for the night shift workers as they recorded about one hour less sleep than the day shift workers. This was below the recommended number of sleep hours prescribed for human efficiency. However, at no point during the harvesting season did the average KSS scores exceed the threshold for excessive sleepiness for both shifts. Furthermore, there was no significant difference in sleepiness over time, thus indicating no increase in sleepiness ratings over the harvest season.

Causal factors contributing to worker fatigue incorporate elements of the individual, the work situation, and the private situation. Elderly sorters experienced higher overall and cognitive fatigue, and sleepiness, while participants with higher perceived levels of health experienced lower levels of physical, cognitive, and psychosocial fatigue. With most of the participants (85%) not completing high school, it was found that all facets of fatigue influenced workers with lower educational levels. Lastly, caffeine consumption before and during the shift was more prominent among the day shift workers, which may justify why day shift workers perceived lower levels of sleepiness.

It was discovered that the effects of shiftwork had a noticeable impact on participants sleeping behaviour, particularly night shift workers, as there was a significant difference in the hours of sleep between the shifts. However, it should be acknowledged that the circadian rhythm can adapt to altered sleep schedules after a week, which may have benefitted night shift workers. Furthermore, environmental readings (temperature, noise, and lighting) were recorded at the end of the shift and revealed that night shift temperatures were lower than during the day shift. In contrast, noise levels were consistent across all shifts (±85 dBA). The highest lighting intensity was recorded during the night shift throughout the study, which was expected due to the additional use of artificial lighting. Nonetheless, it was found that all environmental elements, except for cold temperatures in the night shift, were within the recommended limits for efficient performance; thus, it was unlikely that these elements contributed significantly towards the onset of fatigue. Work output, calculated as the average number of crates sorted per worker, varied considerably from week to week, between 'rooms and shifts. Multiple missing data points were presented, thus making any analysis difficult. However, across all shifts, the last two weeks were identified as having higher workloads.

The private situation for black African women is unique as they are considered the caregivers for the family in aid of absent fathers; thus, workers may have higher domestic work demands when returning home. Most participants (89%) were single or widowed and had, on average, two children and one elderly living in their household. The number of dependents had a minor contribution towards the increased levels of overall, physical, and cognitive fatigue. Only 13 participants regularly performed physical exercise as most workers faced contextual challenges preventing them from exercising. However, there was no significant correlation between frequent or infrequent physical exercise and fatigue or sleepiness.

6.4. LIMITATIONS

6.4.1. Fieldwork constraints

The sample for this study was limited to sorters from one packhouse within the Sundays River Valley; therefore, the study's results can only partially represent citrus sorters within the country, the province, or even within the region. All packhouses have different work systems and organisational characteristics; thus, the work demands may differ considerably from one packhouse to another. Additionally, the participants in this study only represent a fraction of all sorters within the citrus industry in South Africa, and caution must be practised when generalising the results of this study to the rest of this population.

The nature of fieldwork research in general, and specifically within the South African context, provided some challenges that could have impacted the study's findings. For example, labour disputes are an ongoing challenge in all South African industries (Alcock et al., 2022). In this case, the start of the citrus harvesting season was delayed due to protests from failed agreements for increased wages between farm workers and farm owners (Chirume, 2022). These protests turned violent; millions of rands were lost due to property damage, several protestors were arrested, and one resident was killed as a result (Chirume, 2022). These protests forced the entire citrus industry within the SRV to be placed on hold for a month. This, therefore, delayed the data collection period and could have influenced workers' perceptions towards fatigue from the start due to the increased workloads (to catch up on accumulated fruit to be sorted). Additionally, tension within the social environment may have existed between management and the workers due to income disputes and the delayed start.

A further limitation of the current study was that, in recent years, South Africa had been hit with major rolling electricity blackouts (known locally as "load-shedding"), affecting the entire country and its commercial enterprise. The finance minister of South Africa, Mr Enoch Godongwana, stated, "The intensity of load-shedding is having a disastrous effect on our economy" (Omarjee, 2022). Industries whose operations depended on electricity supply have had to use alternative power sources, usually diesel-fuelled generators. However, a diesel shortage and escalating fuel prices make running a generator costly (Omarjee, 2022). Unreliable power sources significantly affect companies' reliance on automation and machinery, such as citrus packhouses. Load-shedding and the consistent use of generators placed a massive strain on the economic expenditure of the packhouse of focus in the study. Therefore, it was not viable to work particular shifts as management was required to lower economic expenditures on generator usage. This contextual hindrance affected the number of participants assessed in certain weeks as particular shifts were not scheduled for work. Furthermore, there was no certainty that shifts (particularly night shifts) would operate, making it difficult for the researchers to schedule testing.

6.4.2. Reflection of tools and method

Limitations of the tools used for the study should also be noted. The MFIS was utilised as an outcome measure for fatigue; however, there were some limitations in interpreting the results. The MFIS scale was initially developed in the clinical setting for patients with multiple sclerosis and has not been used within the work setting. Thus, the scale needs to be verified to be equipped within the workplace to measure fatigue prevalence. Furthermore, to the researcher's knowledge, the MFIS has never been applied within an African context, as most previous studies have used it in a Northern American or European context (Flachenecker et al., 2002; Kos et al., 2005; Téllez et al., 2005). Therefore, the fatigue threshold value of 38 used in this study may be unsuitable due to the North-South disparity. This fatigue threshold is a generalised value, as there are no universal norms due to varying experiences and perceptions of this phenomenon between persons, cultures, or regions. Furthermore, the assessment is subjective; thus, participants may not have answered the questions honestly, again bearing the sensitive labour context in mind. Furthermore, questions may not have been understood, due to language and education challenges, despite attempts to prevent these.

Another limitation of the MFIS was the psychosocial subscale which only asked two questions compared to the nine and ten questions asked by the physical and cognitive sub-scales of the MFIS, respectively. It may not have reflected the complete psychosocial component of fatigue. This issue was experienced by Kos et al. (2005), who recommended interpreting the psychosocial subscale "with caution". To work around this challenge, the MFIS subscale scores were relativised to allow an appropriate comparison between the different subscale scores. Larson (2013) stated that there is a lack of 'agreement' with the psychosocial subscale; however, this can be explained by the fact that research studies utilising this scale included individuals from different cultural backgrounds. The lack of agreement does not invalidate the subscale but suggests that further investigations of different cultural backgrounds as confounding variables should be recognised.

Karpen (2018) recognised that the most common consequence of self-perceived assessments is the bias generated from participants' perceptions of their actual work performance and state of health that produces weak or no correlations with other work variables. The subjective nature of individuals' perceptions would be challenging to grant significant relationships with certain variables, particularly fatigue and sleepiness. This may explain why no moderate or strong significant correlations were formed in the current study, as the KSS, MFIS, and other contextual surveys are self-reported and based on the participant's perceptions.

Certain limitations transpired pertaining to the questions in the repeated assessment. Most questions required the participant's perception of "how they felt now", however, these measurements of their perception may have changed when removing the workers from their regular workstations. Therefore, the participant's perception of "right now" would be considerably different as they could have been more awake than prior to their work interruption. Additionally, question five of the repeated assessment inquired about participants' perceptions of the work-pace for the conveyor belt carrying the fruit 'compared to normal'. Inter-individuality variability may have resulted in each participant perceiving the work-pace differently compared to an absolute 'normal' value.

It was further recognised that the strategy to substitute a value for participants missing data points in the fatigue assessment may have provided a false reflection of their perceptions. These substituted values only accurately represent what participants had previously experienced, which does not provide an accurate representation of their current state. However, a single missing data point would have excluded the participant entirely from the particular assessment. Hence, the supplementation of values provided a greater dataset for the fatigue assessment as it enables participants with missing data points to remain included in the data analysis.

Lastly, the KSS scores of the participants were intended to be recorded at three different intervals throughout the shift to gather an average perception of sleepiness throughout the shift and monitor sleepiness progression. However, packhouse management and logistical reasoning did not permit this procedure; thus, only one KSS score was obtained at the end of the shift.

6.5. RECOMMENDATIONS FOR FUTURE RESEARCH

Future studies should incorporate more qualitative data into the results using focus groups or interviews to analyse worker fatigue further. Such information can be used to understand, in more detail, personal impressions and challenges from the participants' perspectives and allows for the exploration of different viewpoints that may not have been assessed in quantitative research. Focus group discussions are a research technique that engages subjects in an informal interaction where they can express their actions, beliefs, attitudes, and perceptions (Powell & Single, 1996). Focus groups have been viewed as a valuable research tool to analyse a phenomenon that little is known about (Acocella, 2012). This technique can be conducted relatively quickly with low costs. This qualitative form of assessment would assist in understanding how variables that were difficult to measure, such as psychosocial fatigue, are experienced and how workers can cope or recover adequately from possible symptoms of fatigue.

As mentioned previously, there was no certainty that fatigue existed amongst the study population, therefore, the researcher could not assume prior to the research testing that an ergonomics risk assessment was necessary. Based on the evidence from the physical subscale scores and the observations of the working postures held by the sorters, it is recommended that a physical fatigue assessment or an ergonomic risk assessment be considered. The reason is that there is potential for musculoskeletal disorders to occur if adequate recovery is not obtained (Mahdavi et al., 2020). Additionally, an in-depth sleep analysis study would be suitable, particularly targeted at night shift workers. Considering that night shift workers perceived the highest ratings of sleepiness while obtaining lower hours of sleep on average compared to the day shift workers may suggest potential defects in the accuracy of work performance. Furthermore, such studies could contribute to improving and educating stakeholders within the citrus industry on the potential impact of sleep loss and the prevalence of musculoskeletal disorders if workers do not recover adequately.

Lastly, studies should include objective performance measurements to correlate workers' performance (speed and accuracy) with fatigue and sleepiness indicators, for example, by assessing the number of defect fruits missed. However, these objective measurements require collaboration with various stakeholders and a more extensive analysis of which workers were present when defective fruit was found. In contrast, false errors can also be recorded, as fruit that meets the export requirements is sent to local markets or waste bins. Objective measures justify how fatigue prevalence may impact citrus sorters' work accuracy and performance.

REFERENCE LIST

Aaronson, L. S., Pallikkathayil, L., & Crighton, F. (2003). A qualitative investigation of fatigue among healthy working adults. *Western Journal of Nursing Research*, *25*(4), 419–433. https://doi.org/10.1177/0193945903025004007

Aaronson, L. S., Teel, C. S., Cassmeyer, V., Neuberger, G. B., Pallikkathayil, L., Pierce, J., Press, A. N., Williams, P. D., & Wingate, A. (1999). Defining and measuring fatigue. *Journal of Nursing Scholarship*, *31*(1), 45–50. https://doi.org/10.1111/j.1547-5069.1999.tb00420.x

Acocella, I. (2012). The focus groups in social research: Advantages and disadvantages. *Quality and Quantity*, *46*(4), 1125–1136. https://doi.org/10.1007/s11135-011-9600-4

Ahasan, R., Lewko, J., Campbell, D., & Salmoni, A. (2001). Adaptation to night shifts and synchronisation processes of night workers. *Journal of Physiological Anthropology and Applied Human Science*, *20*(4), 215–226. https://doi.org/10.2114/jpa.20.215

Åhsberg, E. (1998). Perceived Fatigue Related To Work. *Psychology*, *19*(National Institute for Working Life), 39. http://www.niwl.se/ah/

Åhsberg, E., Kecklund, G., Åkerstedt, T., & Gamberale, F. (2000). Shiftwork and different dimensions of fatigue. *International Journal of Industrial Ergonomics*, *26*(4), 457–465. https://doi.org/10.1016/S0169-8141(00)00007-X

Åkerstedt, T., Anund, A., Axelsson, J., & Kecklund, G. (2014). Subjective sleepiness is a sensitive indicator of insufficient sleep and impaired waking function. *Journal of Sleep Research*, *23*(3), 242–254. https://doi.org/10.1111/jsr.12158

Åkerstedt, T., Fredlund, P., Gillberg, M., & Jansson, B. (2002). Work load and work hours in relation to disturbed sleep and fatigue in a large representative sample. *Journal of Psychosomatic Research*, *53*, 585–588.

Åkerstedt, T., & Gillberg, M. (1990). Subjective and objective sleepiness in the active individual. *International Journal of Neuroscience*, *52*(1–2), 29–37. https://doi.org/10.3109/00207459008994241

Akoglu, H. (2018). User's guide to correlation coefficients. *Turkish Journal of Emergency Medicine*, *18*(3), 91–93. https://doi.org/10.1016/j.tjem.2018.08.001

Ala-Mursula, L., Vahtera, J., Linna, A., Pentti, J., & Kivimäki, M. (2005). Employee worktime control moderates the effects of job strain and effort-reward imbalance on sickness absence: The 10-town study. *Journal of Epidemiology and Community Health*, *59*(10), 851–857. https://doi.org/10.1136/jech.2004.030924

Alcock, R., le Roux, P., and Braatvedt, M. (2022) The labour and employment disputes review: South Africa. *The Laws Review.* URL: https://thelawreviews.co.uk/title/the-labour-and-employment-disputes-review/south-africa (Last assessed: 10 February 2023).

Ansi/Ashrae. (2004). ANSI/ASHRAE 55:2004 Thermal Environmental Conditions for Human Occupancy. *Ashrae*, *2004*, 30.

Asante, A., & Yin, M. (2019). Optimizing the operational process of a cold chain fruit pack house. *African Journal of Engineering Research*, *7*(3), 64–73. https://doi.org/10.30918/ajer.73.19.017

Bakker, A. B., & Demerouti, E. (2007). The Job Demands-Resources model: State of the art. *Journal of Managerial Psychology*, *22*(3), 309–328. https://doi.org/10.1108/02683940710733115

Bauerle, T., Dugdale, Z., & Poplin, G. (2018). Mineworker fatigue: A review of what we know and future directions. *Vision, Innovation and Identity: Step Change for a Sustainable Future - 2018 SME Annual Conference and Expo and 91st Annual Meeting of the SME-MN Section*, *2018-Febru*(3), 1–19.

Boksem, M. A. S., Meijman, T. F., & Lorist, M. M. (2005). Effects of mental fatigue on attention: An ERP study. *Cognitive Brain Research*, *25*(1), 107–116. https://doi.org/10.1016/j.cogbrainres.2005.04.011

Bollen, F. A., & Prussia, S. E. (2014). Sorting for Defects. *Postharvest Handling: A Systems Approach*, 341–362. https://doi.org/10.1016/B978-0-12-408137-6.00012-0

Bosch, A., de Bruin, G. P., Kgaladi, B., & de Bruin, K. (2012). Life role salience among black African dual-career couples in the South African context. *International Journal of Human Resource Management*, *23*(14), 2835–2853. https://doi.org/10.1080/09585192.2012.671506

Bosch, T., Mathiassen, S. E., Visser, B., de Looze, M. D., & van Dieën, J. V. (2011). The effect of work pace on workload, motor variability and fatigue during simulated light assembly work. *Ergonomics*, *54*(2), 154–168. https://doi.org/10.1080/00140139.2010.538723

Brown, H., & Prescott, R. (2014) Generalized linear mixed models. In *Applied Mixed Models in Medicine* (3rd ed., pp. 113-167) John Wiley & Sons, Ltd. https://doi.org/10.1002/9781118778210

Bryman, A. (2012). Social reseach methods. In *Oxford University Press* (Issue 4th edition).

Caldwell, J. A., Caldwell, J. L., Thompson, L. A., & Lieberman, H. R. (2019). Fatigue and its management in the workplace. *Neuroscience and Biobehavioral Reviews*, *96*(July 2018), 272–289. https://doi.org/10.1016/j.neubiorev.2018.10.024

Carayon, P., Schoofs Hundt, A., Karsh, B. T., Gurses, A. P., Alvarado, C. J., Smith, M., & Brennan, P. F. (2006). Work system design for patient safety: The SEIPS model. *Quality and Safety in Health Care*, *15*(SUPPL. 1), 50–58. https://doi.org/10.1136/qshc.2005.015842

Carayon, Pascale, & Smith, M. J. (2000). Work organization and ergonomics. *Applied Ergonomics*, *31*(6), 649–662. https://doi.org/10.1016/S0003-6870(00)00040-5

Carayon, Pascale, Smith, M. J., & Haims, M. C. (1999). Work Organization, Job Stress, and Work-Related Musculoskeletal Disorders. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *41*(4), 644–663. https://doi.org/10.1518/001872099779656743

Chirume, J. (2022) Thousands of Sundays River Valley farm workers strike for higher wages. *Ground up.* URL: https://www.groundup.org.za/article/thousands-sundays-river-valley-farm-workers-strike-higher-wages/ (Last accessed: 15

November 2022).

Chisoro-Dube, S., & Roberts, S. (2021). *Innovation and inclusion in South Africa's citrus industry*. Working paper, University of Johannesburg, Gauteng, South Africa.

Christodoloulou, C. (2017) Dimensional Models of Fatigue. In G. Matthews, P.A. Desmond, C. Neubauer, P.A. Hancock (Eds), *The Handbook of Operator Fatigue.* Taylor & Francis Group.

Citrus Growers Association, (2007) Annual Report 2007, *Citrus Growers Association of Southern Africa,* Hillcrest, South Africa.

Citrus Growers Association, (2017) Annual Report 2017, *Citrus Growers Association of Southern Africa,* Hillcrest, South Africa.

Citrus Growers Association, (2019) Key Industry Statisics for 2018 Export Season, *Citrus Growers Association of Southern Africa,* Hillcrest, South Africa.

Citrus Growers Association, (2020) Key Industry Statisics for 2019 Export Season, *Citrus Growers Association of Southern Africa,* Hillcrest, South Africa.

Citrus Growers Association, (2021) Key Industry Statisics for 2020 Export Season, *Citrus Growers Association of Southern Africa,* Hillcrest, South Africa.

Citrus Growers Association, (2022) Key Industry Statisics for 2021 Export Season, *Citrus Growers Association of Southern Africa,* Hillcrest, South Africa.

Costa, G. (1996). The impact of shift and night work on health. *Applied Ergonomics*, *27*(1), 9–16. http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L26034384%0Ahttp://dx.doi.org/10.1016/0003-6870(95)00047-X

Costa, G., Barton, J., Spelten, E., Totterdell, P., Smith, L., & Folkard, S. (1995). The Standard Shiftwork Index: a battery of questionnaires for assessing shiftwork-related problems. In *Work and Stress* (Vol. 9, Issue 1, pp. 4–30).

Craig, A., & Cooper, R.E. (1992) Symptoms of Acute and Chronic Fatigue. In A.P.

Smith, & D.M. Jones, (Eds), *Handbook of Human Performance (3),* (pp. 289-340). ACADEMIC PRESS LIMITED.

Dawson, D., Ian Noy, Y., Härmä, M., Kerstedt, T., & Belenky, G. (2011). Modelling fatigue and the use of fatigue models in work settings. *Accident Analysis and Prevention*, *43*(2), 549–564. https://doi.org/10.1016/j.aap.2009.12.030

De Vries, J., Michielsen, H. J., & Van Heck, G. L. (2003). Assessment of fatigue among working people: A comparison of six questionnaires. *Occupational and Environmental Medicine*, *60*(1), 10–15. https://doi.org/10.1136/oem.60.suppl_1.i10

Demerouti, E., Bakker, A. B., Nachreiner, F., & Schaufeli, W. B. (2001). The Job Demands-Resources Model of Burnout. *Journal of Applied Psychology*, *86*(3), 499–512.

Dittner, A. J., Wessely, S. C., & Brown, R. G. (2004). The assessment of fatigue: A practical guide for clinicians and researchers. *Journal of Psychosomatic Research*, *56*(2), 157–170. https://doi.org/10.1016/S0022-3999(03)00371-4

Dlikilili, X., & Van Rooyen, J. (2018). Measuring the competitive trends of the South African citrus industry. *Southern Africa-Towards inclusion growth. SA-TIED Working paper, 11.*

Doyle, C. (1986). *The grading inspection of an agricultural product: Decision-making problems and strategies with their training and selection implications*. Loughborough University.

Eastern Cape Socio-Economic Consultative Council, (2017) Sundays River Valley Local Municipality Socio Economic Review and Outlook, URL: https://www.ecsecc.org/documentrepository/informationcentre/sundays-river-valley-local-municipality_35214.pdf. (Last accessed: 31 January 2023).

Eastern Cape Socio-Economic Consultative Council, (2021) Sundays River Valley Local Municipality Socio Economic Review and Outlook, URL: https://www.ecsecc.org/documentrepository/informationcentre/sundays-river-valley-local-municipality_35214.pdf. (Last accessed: 31 January 2023).

Engberg, I., Segerstedt, J., Waller, G., Wennberg, P., & Eliasson, M. (2017). Fatigue in the general population- associations to age, sex, socioeconomic status, physical activity, sitting time and self-rated health: the northern Sweden MONICA study 2014. *BMC Public Health*, *17*(1), 1–9. https://doi.org/10.1186/s12889-017-4623-y

Fang, J., Qiu, C., Xu, H., & You, G. (2013). A model for predicting acute and chronic fatigue in Chinese nurses. *Journal of Advanced Nursing*, *69*(3), 546–558. https://doi.org/10.1111/j.1365-2648.2012.06029.x

Finsterer, J., & Mahjoub, S. Z. (2014). Fatigue in Healthy and Diseased Individuals. *American Journal of Hospice and Palliative Medicine*, *31*(5), 562–575. https://doi.org/10.1177/1049909113494748

Flachenecker, P., Kümpfel, T., Kallmann, B., Gottschalk, M., Grauer, O., Rieckmann, P., Trenkwalder, C., & Toyka, K. V. (2002). Fatigue in multiple sclerosis: A comparison of different rating scales and correlation to clinical parameters. *Multiple Sclerosis*, *8*(6), 523–526. https://doi.org/10.1191/1352458502ms839oa

Florkowski, W. J., Shewfelt, R. L., Brueckner, B., & Prussia, S. E. (2014). Challenges in Postharvest Handling. *Postharvest Handling: A Systems Approach*, *Chapter 9*, 543–547. https://doi.org/10.1016/B978-0-12-408137-6.00020-X

Folkard, S., & Tucker, P. (2003). Shift work, safety and productivity. *Occupational Medicine*, *53*(2), 95–101. https://doi.org/10.1093/occmed/kqg047

Follett, P. A., & Neven, L. G. (2006). Current trends in quarantine entomology. *Annual Review of Entomology*, *51*(108), 359–385. https://doi.org/10.1146/annurev.ento.49.061802.123314

Geiger Brown, J., Wieroney, M., Blair, L., Zhu, S., Warren, J., Scharf, S. M., & Hinds, P. S. (2014). Measuring subjective sleepiness at work in hospital nurses: validation of a modified delivery format of the Karolinska Sleepiness Scale. *Sleep and Breathing*, *18*(4), 731–739. https://doi.org/10.1007/s11325-013-0935-z

Genis, A. (2018). Oranges and labourers: The potential for job creation in the citrus sub-sector of South Africa. *Working Paper 54.* PLAAS, UWC: Cape Town.

Gibson, A. S. C., Baden, D. A., Lambert, M. I., Lambert, E. V., Harley, X. R., Hampson, D., Russell, V. A., & Noakes, T. D. (2003). The Conscious Perception of the Sensation of Fatigue. *Sports Medicine*, *33*(3), 1–10. http://link.springer.com/article/10.2165/00007256-200333030-00001

Gillberg, M., Kecklund, G., & Akerstedt, T. (1994). Relations between performance and subjective ratings of sleepiness during a night awake. *Sleep*, *17*(3), 236–241. https://doi.org/10.1093/sleep/17.3.236

Gilsoul, J., Simon, J., Hogge, M., & Collette, F. (2019). Do attentional capacities and processing speed mediate the effect of age on executive functioning? *Aging, Neuropsychology, and Cognition*, *26*(2), 282–317. https://doi.org/10.1080/13825585.2018.1432746

Grandjean, E. (1979). Fatigue in industry. *British Journal of Industrial Medicine*, *36*(3), 175–186. https://doi.org/10.1136/oem.36.3.175

Halim, I., Omar, A. R., Saman, A. M., & Othman, I. (2012). Assessment of muscle fatigue associated with prolonged standing in the workplace. *Safety and Health at Work*, *3*(1), 31–42. https://doi.org/10.5491/SHAW.2012.3.1.31

Han, K., Trinkoff, A. M., & Geiger-Brown, J. (2014). Factors associated with work-related fatigue and recovery in hospital nurses working 12-hour shifts. *Workplace Health and Safety*, *62*(10), 409–414. https://doi.org/10.3928/21650799-20140826-01

Hattingh, V., Moore, S., Kirkman, W., Goddard, M., Thackeray, S., Peyper, M., Sharp, G., Cronjé, P., Pringle, K., & Cha, D. H. (2020). An Improved Systems Approach as a Phytosanitary Measure for Thaumatotibia leucotreta (Lepidoptera: Tortricidae) in Export Citrus Fruit from South Africa. *Journal of Economic Entomology*, *113*(2), 700–711. https://doi.org/10.1093/jee/toz336

Head, J., & Helton, W. S. (2014). Sustained attention failures are primarily due to sustained cognitive load not task monotony. *Acta Psychologica*, *153*, 87–94. https://doi.org/10.1016/j.actpsy.2014.09.007

Hendrick, H. W. (1996). The ergonomics of economics is the economics of ergonomics. *Proceedings of the Human Fators and Ergonomics Society Annual Meeting* (Vol. 40, No. 1, pp. 1-10). Sage CA: Los Angeles, CA: Sage Publications.

Hobfoll, S. E. (2001). The influence of culture, community, and the nested-self in the stress process: Advancing conservation of resources theory. *Applied Psychology*, *50*(3), 337–421. https://doi.org/10.1111/1464-0597.00062

Horrey, W. J., Noy, Y. I., Folkard, S., Popkin, S. M., Howarth, H. D., & Courtney, T. K. (2011). Research needs and opportunities for reducing the adverse safety consequences of fatigue. *Accident Analysis and Prevention*, *43*(2), 591–594. https://doi.org/10.1016/j.aap.2010.01.014

Johansson, S., Ytterberg, C., Back, B., Holmqvist, L. W., & von Koch, L. (2008). The Swedish Occupational Fatigue Inventory in people with multiple sclerosis. *Journal of Rehabilitation Medicine*, *40*(9), 737–743. https://doi.org/10.2340/16501977-0236

Johns, M. W. (1991). A new method for measuring daytime sleepiness: The Epworth sleepiness scale. *Sleep*, *14*(6), 540–545. https://doi.org/10.1093/sleep/14.6.540

Jorgensen, R. (2008). Chronic fatigue: An evolutionary concept analysis. *Journal of Advanced Nursing*, *63*(2), 199–207. https://doi.org/10.1111/j.1365-2648.2008.04649.x

Kaida, K., Takahashi, M., Åkerstedt, T., Nakata, A., Otsuka, Y., Haratani, T., & Fukasawa, K. (2006). Validation of the Karolinska sleepiness scale against performance and EEG variables. *Clinical Neurophysiology*, *117*(7), 1574–1581. https://doi.org/10.1016/j.clinph.2006.03.011

Kajtna, T., Štukovnik, V., & Dolenc-Grošelj, L. (2011). Effect of acute sleep deprivation on concentration and mood states with a controlled effect of experienced stress. *Zdravniški Vestnik*, *5*(80), 354–361.

Kant, I. J., Schroer, K. A. P., Beurskens, A. J. H. M., van Amelsvoort, L. G. P. M., & Swaen, G. M. H. (2003). An epidemiological approach to study fatigue in the working population: the Maastricht Cohort Study. *Occupational Environmental Medicine*, *60*(Occup Environ Med), 32–39.

Karpen, S. C. (2018). The social psychology of biased self-assessment. *American Journal of Pharmaceutical Education*, *82*(5), 441–448. https://doi.org/10.5688/ajpe6299

Kilbom, Å., Armstrong, T., Buckle, P., Fine, L., Hagberg, M., Haring-Sveeney, M., Martin, B., Punnett, L., Silverstein, B., Sjøgaard, G., Theorell, T., & Viikari-Juntura, E. (1996). Musculoskeletal disorders: Work-related risk factors and prevention. *International Journal of Occupational and Environmental Health*, *2*(3), 239–246. https://doi.org/10.1179/oeh.1996.2.3.239

Kocalevent, R. D., Hinz, A., Brähler, E., & Klapp, B. F. (2011). Determinants of fatigue and stress. *BMC Research Notes*, *4*, 0–4. https://doi.org/10.1186/1756-0500-4-238

Kołodziej, S., & Ligarski, M. J. (2017). The Influence of Physical Fatigue on Work on a Production Line. *Acta Technologica Agriculturae*, *20*(3), 63–68. https://doi.org/10.1515/ata-2017-0013

Kolus, A., Wells, R., & Neumann, P. (2018). Production quality and human factors engineering: A systematic review and theoretical framework. *Applied Ergonomics*, *73*(October 2017), 55–89. https://doi.org/10.1016/j.apergo.2018.05.010

Kos, D., Kerckhofs, E., Carrea, I., Verza, R., Ramos, M., & Jansa, J. (2005). Evaluation of the Modified Fatigue Impact Scale in four different European countries. *Multiple Sclerosis*, *11*(1), 76–80. https://doi.org/10.1191/1352458505ms1117oa

Larsen, M.N., & Fold, N. (2008) Globalization as marginalization of African economies? In N. Fold, & M. Nylandsted Larsen (Eds.), *Globalization and Restructuring of African Commodity Flows.* pp. 9-25.

Larson, R. D. (2013). Psychometric properties of the modified fatigue impact scale. *International Journal of MS Care*, *15*(1), 15–20. https://doi.org/10.7224/1537-2073.2012-019

Lawan, I., Yahaya, K., Ahmad, R. K., & Muhammad, A. I. (2018). Ergonomic evaluation of subjects involved in orange (*Citrus sinensis*) handling operations in Yanlemo Market Kano State. *Bayero Journal of Pure and Applied Sciences*, *10*(2), 93.

https://doi.org/10.4314/bajopas.v10i2.16

Learmonth, Y. C., Dlugonski, D., Pilutti, L. A., Sandroff, B. M., Klaren, R., & Motl, R. W. (2013). Psychometric properties of the Fatigue Severity Scale and the Modified Fatigue Impact Scale. *Journal of the Neurological Sciences*, *331*(1–2), 102–107. https://doi.org/10.1016/j.jns.2013.05.023

Lerman, S. E., Eskin, E., Flower, D. J., George, E. C., Gerson, B., Hartenbaum, N., Hursh, S. R., & Moore-Ede, M. (2012). Fatigue risk management in the workplace. *Journal of Occupational and Environmental Medicine*, *54*(2), 231–258. https://doi.org/10.1097/JOM.0b013e318247a3b0

LibreTexts Statistics, (2023) Testing the Significance of the Correlation Coefficient, *LibreTexts Statistics,* URL: https://stats.libretexts.org/Bookshelves/Introductory_Statistics/Introductory_Statistics_(OpenStax)/12%3A_Linear_Regression_and_Correlation/12.05%3A_Testing_the_Significance_of_the_Correlation_Coefficient#:~:text=If%20the%20test%20concludes%20that,correlation%20coefficient%20is%20%22significant.%22 (Last accessed: 19 July 2023).

Loge, J. H., Ekeberg, Ø., & Kaasa, S. (1998). Fatigue in the general Norwegian population: Normative data and associations. *Journal of Psychosomatic Research*, *45*(1), 53–65. https://doi.org/10.1016/S0022-3999(97)00291-2

Loukidou, L., Loan-Clarke, J., & Daniels, K. (2009). Boredom in the workplace: More than monotonous tasks. *International Journal of Management Reviews*, *11*(4), 381–405. https://doi.org/10.1111/j.1468-2370.2009.00267.x

Lu, L., Sesek, R. F., Megahed, F. M., & Cavuoto, L. A. (2017). A survey of the prevalence of fatigue, its precursors and individual coping mechanisms among U.S. manufacturing workers. *Applied Ergonomics*, *65*, 139–151. https://doi.org/10.1016/j.apergo.2017.06.004

Maclean, A. W., Fekken, G. C., Saskin, P., & Knowles, J. B. (1992). Psychometric evaluation of the Stanford Sleepiness Scale. *Journal of Sleep Research*, *1*(1), 35–39. https://doi.org/10.1111/j.1365-2869.1992.tb00006.x

Mahdavi, N., Dianat, I., Heidarimoghadam, R., Khotanlou, H., & Faradmal, J. (2020). A review of work environment risk factors influencing muscle fatigue. *International Journal of Industrial Ergonomics*, *80*(September), 103028. https://doi.org/10.1016/j.ergon.2020.103028

Maslach, C., & Leiter, M. P. (2008). Early Predictors of Job Burnout and Engagement. *Journal of Applied Psychology*, *93*(3), 498–512. https://doi.org/10.1037/0021-9010.93.3.498

Matthews. G., Desmond, P.A., & Hitchock, E.M. (2017), Dimensional Models of Fatigue. In G. Matthews, P.A. Desmond, C. Neubauer, P.A. Hancock (Eds), *The Handbook of Operator Fatigue.* Taylor & Francis Group.

Mehta, R. K., & Parasuraman, R. (2014). Effects of mental fatigue on the development of physical fatigue: A neuroergonomic approach. *Human Factors*, *56*(4), 645–656. https://doi.org/10.1177/0018720813507279

Meijman, T. F. (1997). Mental fatigue and the efficiency of information processing in relation to work times. *International Journal of Industrial Ergonomics*, *20*(1), 31–38. https://doi.org/10.1016/S0169-8141(96)00029-7

Meintjes, F., (2018) A unique citrus setting, *Eurofruit.* URL: http://c1e39d912d21c91dce811d6da9929ae8.cdn.ilink247.com/ClientFiles/cga/CitrusGowersAssociation/Company/Documents/Eurofruit%20article%20on%20Sundays%20River%20by%20Fred%20Meintjes.pdf (Last accessed: 24 August 2021).

Meyers, J. B., Prussia, S. E., Thai, C. N., Sadosky, T. L., & Campbell, D. T. (1990). Visual inspection of agricultural products moving along sorting conveyors. *Transactions of the American Society of Agricultural Engineers*, *33*(2), 367–372. https://doi.org/10.13031/2013.31339

Michielsen, H. J., De Vries, J., Van Heck, G. L., Van de Vijver, F. J. R., & Sijtsma, K. (2004). Examination of the Dimensionality of Fatigue: The Construction of the Fatigue Assessment Scale (FAS). *European Journal of Psychological Assessment*, *20*(1), 39–48. https://doi.org/10.1027/1015-5759.20.1.39

Miley, A., Kecklund, G., & Åkerstedt, T. (2016). Comparing two versions of the Karolinska Sleepiness Scale (KSS). *Sleep and Biological Rhythms*, *14*(3), 257–260. https://doi.org/10.1007/s41105-016-0048-8

Mogala, M. (2015) A profile of South African citrus market value chain. *Department of Agriculture, Forestry, and Fisheries.* URL: http://www.nda.agric.za/doaDev/sideMenu/Marketing/Annual%20Publications/Commodity%20Profiles/FRUITS%20AND%20VEGETABLES/Citrus%20market%20v alue%20chain%202015.pdf. (Last accessed: 5 August 2021).

Mota, D. D. C. F., & Pimenta, C. A. M. (2006). Self-report instruments for fatigue assessment: a systematic review. *Research and Theory for Nursing Practice*, *20*(1), 49–78. https://doi.org/10.1891/rtnp.20.1.49

Murphy, L. A., Robertson, M. M., & Carayon, P. (2014). The next generation of macroergonomics: Integrating safety climate. *Accident Analysis and Prevention*, *68*, 16–24. https://doi.org/10.1016/j.aap.2013.11.011

National Research Concil and Institute of Medicine, (2013). U.S. Health In International Perspective: Shorter lives, Poorer Health. Panel on Understanding Cross-National Health Diifferences Among High-Income Countries. In S.H. Woolf, and L. Aron (Eds) *Committee on Population, Division of Behavioural and Social Science and Education, and Board on Population Health and Public Health Practice, Instituite of Medicine.* Washington DC: The National Academics Pres.

Ndou, P., & Obi, A. (2015). The buisness environment and international competitiveness of the South African citrus industry. *International Food and Agribuisness Association (IFAMA) Ls 21st World Annual Forum and Symposium. June* (pp. 20-23).

Neu, D., Kajosch, H., Peigneux, P., Verbanck, P., Linkowski, P., & Le Bon, O. (2011). Cognitive impairment in fatigue and sleepiness associated conditions. *Psychiatry Research*, *189*(1), 128–134. https://doi.org/10.1016/j.psychres.2010.12.005

Neuberger, G. B. (2003). Measures of fatigue: The Fatigue Questionnaire, Fatigue Severity Scale, Multidimensional Assessment of Fatigue Scale, and Short Form-

36 Vitality (Energy/Fatigue) Subscale of the Short Form Health Survey. *Arthritis & Rheumatism*, *49*(S5), S175–S183. https://doi.org/10.1002/art.11405

Nicolaï, B., Bulens, I., De Baerdemaeker, J., De Ketelaere, B., Lammertyn, J., Saeys, W., Verboven, P., & Hertog, M. (2014). Non-destructive Evaluation: Detection of External and Internal Attributes Frequently Associated with Quality and Damage. In *Postharvest Handling* (Vol. 2, Issue 1, pp. 363–385). Elsevier. https://doi.org/10.1016/B978-0-12-408137-6.00012-0

Noy, Y. I., Horrey, W. J., Popkin, S. M., Folkard, S., Howarth, H. D., & Courtney, T. K. (2011). Future directions in fatigue and safety research. *Accident Analysis and Prevention*, *43*(2), 495–497. https://doi.org/10.1016/j.aap.2009.12.017

Omarjee, L (2022) R15bn, maybe more: Eskom braces for soaring diesel costs as it battles load shedding. *News24.* URL: https://www.news24.com/fin24/economy/r15bn-maybe-more-eskom-braces-for-soaring-diesel-costs-as-it-battles-load-shedding-20220511 (Last accessed: 16 November 2022).

Ora, C. D., Ball, J., Recio-saucedo, A., & Griffiths, P. (2016). International Journal of Nursing Studies Characteristics of shift work and their impact on employee performance and wellbeing : A literature review §. *International Journal of Nursing Studies*, *57*, 12–27. https://doi.org/10.1016/j.ijnurstu.2016.01.007

Pigeon, W. R., Sateia, M. J., & Ferguson, R. J. (2003). Distinguishing between excessive daytime sleepiness and fatigue: Toward improved detection and treatment. *Journal of Psychosomatic Research*, *54*(1), 61–69. https://doi.org/10.1016/S0022-3999(02)00542-1

Powell, R., & Single, H. (1996). Focus Groups. *International Journal for Quality in Health Care*, *8*(5), 499–504. https://doi.org/10.1201/b19093

Rahimian Aghdam, S., Alizadeh, S. S., Rasoulzadeh, Y., & Safaiyan, A. (2019). Fatigue Assessment Scales: A comprehensive literature review. *Archives of Hygiene Sciences*, *8*(3), 145–153. https://doi.org/10.29252/archhygsci.8.3.145

Rasmussen, J. (1997). Risk management in a dynamic society: A modelling problem.

Safety Science, *27*(2/3), 183–213. https://doi.org/SO9257535(97MOO52-0

Rotenberg, L., Silva-Costa, A., Diniz, T. B., & Griep, R. H. (2011). Long-term deleterious effects of night work on sleep. *Sleep Science*, *4*(1), 13-20.

SA Fruit Journal, (2009) Sundays River Valley, the place in between. *Citrus Warehouse resource.* URL: https://www.citrusresourcewarehouse.org.za/home/document-home/news-articles/south-african-fruit-journal-safj/safj-2008/2467-sa-fruit-journal-dec-2008-jan-2009-sundays-river-valley-place-inbetween/file (Last accessed 25 January 2023).

SADHS, (2016) South African Demographic and Health Survey. URL: https://dhsprogram.com/pubs/pdf/FR337/FR337.pdf (Last accessed: 9 December 2022).

Saito, K. (1999). Measurement of fatigue in industries. *Industrial Health*, *37*(2), 134–142. https://doi.org/10.2486/indhealth.37.134

Salters-Pedneault, K. (2020) The use of self-reported data in psychology. *VeryWellMind.* URL: https://www.verywellmind.com/definition-of-self-report-425267 (Last accessed: 6 May 2022).

Samaha, E., Lal, S., Samaha, N., & Wyndham, J. (2007). Psychological, lifestyle and coping contributors to chronic fatigue in shift-worker nurses. *Journal of Advanced Nursing*, *59*(3), 221–232. https://doi.org/10.1111/j.1365-2648.2007.04338.x

Sanders, M.S., & McCormick, E.J. (1993) Environmental conditions. In M.S. Sanders., & E.J. McCormick (Eds), *Human Factors in Engineering and Design, 7,* (pp. 530), McGraw-Hill International Editions.

Satterfield, B. C., & Van Dongen, H. P. A. (2013). Occupational fatigue, underlying sleep and circadian mechanisms, and approaches to fatigue risk management. *Fatigue: Biomedicine, Health and Behavior*, *1*(3), 118–136. https://doi.org/10.1080/21641846.2013.798923

Schutte, P. (2006). Travel , fatigue and work. *Occupational Health Southern Africa*, 12–15.

Sedighi Maman, Z., Alamdar Yazdi, M. A., Cavuoto, L. A., & Megahed, F. M. (2017). A data-driven approach to modeling physical fatigue in the workplace using wearable sensors. *Applied Ergonomics*, *65*, 515–529. https://doi.org/10.1016/j.apergo.2017.02.001

Shahid, A., Shen, J., & Shapiro, C. M. (2010). Measurements of sleepiness and fatigue. *Journal of Psychosomatic Research*, *69*(1), 81–89. https://doi.org/10.1016/j.jpsychores.2010.04.001

Shahid, A., Wilkinson, K., Marcu, S., & Shapiro, C. M. (2012). STOP, THAT and one hundred other sleep scales. *STOP, THAT and One Hundred Other Sleep Scales*, *5*, 1–406. https://doi.org/10.1007/978-1-4419-9893-4

Shen, J., Barbera, J., & Shapiro, C. M. (2006). Distinguishing sleepiness and fatigue: Focus on definition and measurement. *Sleep Medicine Reviews*, *10*(1), 63–76. https://doi.org/10.1016/j.smrv.2005.05.004

Shen, J., & Dicker, B. (2008). The impacts of shiftwork on employees. *International Journal of Human Resource Management*, *19*(2), 392–405. https://doi.org/10.1080/09585190701799978

Shen, R., Weng, D., Chen, S., Guo, J., & Fang, H. (2019). Mental fatigue of long-Term office tasks in virtual environment. *Adjunct Proceedings of the 2019 IEEE International Symposium on Mixed and Augmented Reality, ISMAR-Adjunct 2019*, *October*, 124–127. https://doi.org/10.1109/ISMAR-Adjunct.2019.00-65

Simcox, N., Flanagan, M. E., & Camp, J. (2001). Musculoskeletal risks in Washington State apple packing companies. *Field Research & Consultation Group, University of Washington, Department of Environmental Health. Seattle*.

Sluiter, J. K., De Croon, E. M., Meijman, T. F., & Frings-Dresen, M. H. W. (2003). Need for recovery from work related fatigue and its role in the development and prediction of subjective health complaints. *Occupational and Environmental Medicine*, *60*(SUPPL. 1), 62–70. https://doi.org/10.1136/oem.60.suppl_1.i62

Smith, C., (2021) Another record export season for SA citrus, but picture not as rosy as it seems. *Fin24.* URL: https://www.news24.com/fin24/companies/agribusiness/another-record-export-season-for-sa-citrus-but-picture-not-as-rosy-as-it-seems-20211130 (Last accessed: 13 May 2022).

StatsSA, (2011) Local Municipality, Sundays River Valley. URL: https://www.statssa.gov.za/publications/P0302/P03022022.pdf (Last accessed: 5 August 2021).

StatsSA, (2022) Mid-year population estimates. URL: https://www.statssa.gov.za/publications/P0302/P03022022.pdf (Last accessed: 9 December 2022).

Stein, K. D., Jacobsen, P. B., Blanchard, C. M., & Thors, C. (2004). Further validation of the multidimensional fatigue symptom inventory-short form. *Journal of Pain and Symptom Management*, *27*(1), 14–23. https://doi.org/10.1016/j.jpainsymman.2003.06.003

Stoddard, E., (2021) Agricultural rebound: South Africa's citrus exports heading for a record year. *Buisness Maverick.* URL: https://www.dailymaverick.co.za/article/2021-06-16-agricultural-rebound-south-africas-citrus-exports-heading-for-a-record-year/ (Last accessed: 4 August 2021).

Studman, C. (1998). Ergonomics in apple sorting: A pilot study. *Journal of Agricultural and Engineering Research*, *70*(4), 323–334. https://doi.org/10.1006/jaer.1998.0273

SupplyWise, (2023) Bulk Bin - solid - 1000kg - plastic - grey - 0095. URL: https://www.supplywise.co.za/msj-0095-bulk-bin (Last accessed 31 January 2023).

Tashakkori, A., & Creswell, J. W. (2007). Editorial: The New Era of Mixed Methods. *Journal of Mixed Methods Research*, *1*(1), 3–7. https://doi.org/10.1177/2345678906293042

Techera, U., Hallowell, M., Stambaugh, N., & Littlejohn, R. (2016). Causes and consequences of occupational fatigue: Meta-Analysis and systems model. *Journal of Occupational and Environmental Medicine*, *58*(10), 961–973. https://doi.org/10.1097/JOM.0000000000000837

Téllez, N., Río, J., Tintoré, M., Nos, C., Galán, I., & Montalban, X. (2005). Does the modified fatigue impact scale offer a more comprehensive assessment of fatigue in MS? *Multiple Sclerosis*, *11*(2), 198–202. https://doi.org/10.1191/1352458505ms1148oa

Theron, W. J., & Van Heerden, G. M. J. (2011). Fatigue knowledge-a new lever in safety management. *Journal of the Southern African Institute of Mining and Metallurgy*, *111*(1), 1–10.

Thomas, K., Nilsson, E., Festin, K., Henriksson, P., Lowén, M., Löf, M., & Kristenson, M. (2020). Associations of psychosocial factors with multiple health behaviors: A population-based study of middle- aged men and women. *International Journal of Environmental Research and Public Health*, *17*(4). https://doi.org/10.3390/ijerph17041239

Tucker, P., Lombardi, D., Smith, L., & Folkard, S. (2006). The impact of rest breaks on temporal trends in injury risk. *Chronobiology International*, *23*(6), 1423–1434. https://doi.org/10.1080/07420520601070315

Tucker, P., Folkard, S. (2017) Dimensional Models of Fatigue. In G. Matthews, P.A. Desmond, C. Neubauer, P.A. Hancock (Eds), *The Handbook of Operator Fatigue.* Taylor & Francis Group.

Valko, P. O., Bassetti, C. L., Bloch, K. E., Held, U., & Baumann, C. R. (2008). Validation of the fatigue severity scale in a Swiss cohort. *Sleep*, *31*(11), 1601–1607. https://doi.org/10.1093/sleep/31.11.1601

Verdonk, P., Hooftman, W. E., Van Veldhoven, M. J. P. M., Boelens, L. R. M., & Koppes, L. L. J. (2010). Work-related fatigue: The specific case of highly educated women in the Netherlands. *International Archives of Occupational and Environmental Health*, *83*(3), 309–321. https://doi.org/10.1007/s00420-009-0481-y

Walter, C. M., & du Rosa, R. (2011). Socio-cultural barriers to physical activity among black isixhosa speaking professional women in the Nelson Mandela metropolitan municipality. *South African Journal for Research in Sport, Physical Education and Recreation*, *33*(2), 143–155. https://doi.org/10.4314/sajrs.v33i2.69698

Warm, J. S., Matthews, G., & Finomore, V.S. Jr. (2008). Vigilance , Workload , and Stress. In *Performance under stress* (pp. 131-158). CRC Press.

Waters, T. R., & Dick, R. B. (2015). Evidence of health risks associated with prolonged standing at work and intervention effectiveness. *Rehabilitation Nursing*, *40*(3), 148–165. https://doi.org/10.1002/rnj.166

Westaway, A. (2012). Rural poverty in the Eastern Cape Province: Legacy of apartheid or consequence of contemporary segregationism? *Development Southern Africa*, *29*(1), 115–125. https://doi.org/10.1080/0376835X.2012.645646

Williamson, A., & Friswell, R. (2013). Fatigue in the workplace: causes and countermeasures. *Fatigue: Biomedicine, Health and Behavior*, *1*(1–2), 81–98. https://doi.org/10.1080/21641846.2012.744581

Williamson, A., Lombardi, D. A., Folkard, S., Stutts, J., Courtney, T. K., & Connor, J. L. (2011). The link between fatigue and safety. *Accident Analysis and Prevention*, *43*(2), 498–515. https://doi.org/10.1016/j.aap.2009.11.011

Wilson, J. R. (2000). Fundamentals of ergonomics in theory and practice. *Applied Ergonomics*, *31*(6), 557–567. https://doi.org/10.1016/S0003-6870(00)00034-X

Winwood, P. C., Lushington, K., & Winefield, A. H. (2006). Further development and validation of the Occupational Fatigue Exhaustion Recovery (OFER) scale. *Journal of Occupational and Environmental Medicine*, *48*(4), 381–389. https://doi.org/10.1097/01.jom.0000194164.14081.06

Winwood, P. C., Winefield, A. H., Dawson, D., & Lushington, K. (2005). Development and validation of a scale to measure work-related fatigue and recovery: The Occupational Fatigue Exhaustion/Recovery scale (OFER). *Journal of Occupational and Environmental Medicine*, *47*(6), 594–606. https://doi.org/10.1097/01.jom.0000161740.71049.c4

Winwood, P. C., Winefield, A. H., & Lushington, K. (2006). Work-related fatigue and recovery: The contribution of age, domestic responsibilities and shiftwork. *Journal of Advanced Nursing*, *56*(4), 438–449. https://doi.org/10.1111/j.1365-2648.2006.04011.x

Xanthopoulou, D., Bakker, A. B., Demerouti, E., & Schaufeli, W. B. (2007). The role of personal resources in the job demands-resources model. *International Journal of Stress Management*, *14*(2), 121–141. https://doi.org/10.1037/1072-5245.14.2.121

Yaptenco, K. ., & Esguerra, E. . (2012). Good practice in the design, management and operation of a fresh produce packing-house. *Bangkok: Rap Publication*.

Yazdi, Z., & Sadeghniiat-Haghighi, K. (2015). Fatigue management in the workplace. *Industrial Psychiatry Journal*, *24*(1), 12. https://doi.org/10.4103/0972-6748.160915

Yumang-Ross, D. J., & Burns, C. (2014). Shift Work and Employee Fatigue. *Workplace Health & Safety*, *62*(6), 256–261. https://doi.org/10.1177/216507991406200606

Yung, M., Bigelow, P. L., Hastings, D. M., & Wells, R. P. (2014). Detecting within- and between-day manifestations of neuromuscular fatigue at work: an exploratory study. *Ergonomics*, *57*(10), 1562–1573. https://doi.org/10.1080/00140139.2014.934299

APPENDICES

APPENDIX A – EXPERIMENTAL TOOLS

A.1: RESEARCH SCHEDULE

Table 15: Assessment schedule that was followed for the study.

	DAY SHIFT GROUP 1	NIGHT SHIFT	DAY SHIFT GROUP 2
WEEK 1	7 June 2022 (Tuesday)	7 June 2022 (Tuesday)	8 June 2022 (Wednesday)
WEEK 2	29 June 2022 (Wednesday)	29 June 2022 (Wednesday)	30 June 2022 (Thursday)
WEEK 3	21 July 2022 (Thursday)	21 July 2022 (Thursday)	22 June 2022 (Friday)
WEEK 4	10 August 2022 (Wednesday)	10 August 2022 (Wednesday)	11 August 2022 (Thursday)
WEEK 5	29 August 2022 (Monday)	29 August 2022 (Monday)	30 August 2022 (Tuesday)
WEEK 6	20 September 2022 (Tuesday)	20 September 2022 (Tuesday)	21 September 2022 (Wednesday)

A.2: BACKGROUND QUESTIONNAIRE

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

An investigation into fatigue prevalence amongst citrus packhouse sorters in the Eastern Cape Province of South Africa

This once-off survey asks some general questions about yourself as well as aspects of your work schedule. All data collected are confidential and will be strictly anonymous. Please answer all questions honestly, but you may choose not to answer certain questions, if they make you feel uncomfortable.

Date: ______________________

Time: ______________________

Packhouse code: ___________________________

Participant name/code: ____

SECTION 1: DEMOGRAPHIC INFORMATION

Please answer the following questions as accurately as possible. Answer the questions by either ticking the most appropriate answer or providing details where indicated.

1.1 What gender do you identify as?

☐ Male
☐ Female
☐ Other

1.2 How old are you?

________________ years.

1.3 What is your home language?

☐ Afrikaans
☐ English

☐isiXhosa

☐Other: Please specify, ____________________________

1.4 What is your race group?

☐White

☐Coloured

☐Black African

☐Indian

☐Asian

☐Other: Please specify _____________________________

1.5 What is your marital status?

☐Married

☐Divorced

☐Single/ Unmarried

☐Single/ Unmarried, but living with a partner

☐Widow/Widower

1.6 How many dependents are in your family?

Children: _____________

Adults/Elderly: ______________

1.7 What is your highest level of education you have passed? (e.g., Grade 10, completed matric, bachelors degree).

____

1.8 Do you have any chronic illnesses/ diseases? (e.g., HIV, diabetes, cardiovascular disease, arthritis, hypertension.)

☐Yes

☐No

☐Prefer not to say

1.9 In general, how would you classify your health?

☐Very poor

☐Poor

☐Fair

☐Good

☐Very good

☐Prefer not to say

1.10 On a weekly basis, do you regularly smoke, drink, or use other substances?

☐Yes

☐No

☐Sometimes

☐Prefer not to say

1.11 How often do you exercise?

☐Daily

☐3 times a week

☐Once a week

☐Once a month

☐Almost never

☐Prefer not to say

<u>SECTION 2: WORK-RELATED INFORMATION</u>

2.1 What is your position at the company you are currently employed at?

____

2.2 How many years have you been employed by the current packhouse?

______________________ years

2.3 How many years have you worked as a sorter?

_______________________ years

2.4 What transport do you use to get to work?

☐Company transport

☐Private transport

☐Public transport

☐Walk/cycle

☐A combination of all the above

2.5 Do you work night shift at the company you are employed at?

☐Yes

☐No

2.6 Are you required to ever work overtime?

☐Never

☐Seldom

☐Sometimes

☐Often

☐Always

2.7 Have you completed any training or training courses for your work position this year?

☐Yes

☐No

2.8 Do you have a second paid job in addition to the one you work now?

☐Yes

☐No

END

Thank you for completing this survey! Your time and effort are greatly appreciated. Please make sure all questions are filled out and return the form to the researcher.

A.3: REPEATED ASSESSMENT

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

Date/ Umhla**:** ______________________

Time/Xesha**:** ______________________

Shift: DAY / NIGHT

Participant name/ igama**:** ________________________

The following questions are directed at understanding your perceptions of fatigue/alertness as well as factors that may influence these. Please answer each question honestly and ask the researcher to explain any words or phrases that you do not understand.

Le mibuzo ilandelayo ijolise ekuqondeni iimbono zakho ngokudinwa/ukuphaphama kunye nezinto ezinokuphembelela ezi. Nceda uphendule umbuzo ngamnye ngokunyaniseka kwaye ucele umphandi ukuba achaze nawaphi na amagama okanye amabinzana ongawaqondiyo.

1. **What time did you wake up for work today?**
   Uvuke ngobani ixesha namhlanje?

   ____

2. **On average, how many hours of sleep did you get each night in the past week?**
   Ulala iiyure ezingaphi phakathi evekini?
   _____________________________ hours

3. **Did you consume some form of drink that contains caffeine BEFORE your shift (i.e., coffee, Coca-Cola, energy drinks, tea, supplements)?**
   Bukhe wasela iziselo ezine caffeine ngaphakathi, NGAPHAMBI iqhale ishift yakho (izinto ezifane nje ngeCoca-Cola, energy drinks, iti okanye iisupplements)?
   ☐Yes
   ☐No

4. **Did you consume some form of drink that contains caffeine DURING your shift (i.e., coffee, Coca-Cola, energy drinks, tea, supplements)?**

   Bukhe wasela iziselo ezine caffeine ngaphakathi, NGEXESHA le shift yakho (izinto ezifane nje ngeCoca-Cola, energy drinks, iti okanye iisupplements)?

   ☐Yes
   ☐No

5. **Compared to normal, how do you perceive the work pace of the flow of the fruit on the conveyor belt to be manageable in this shift?**
   Xa kuthelekiswa nesiqhelo, uwubona njani isantya yeziqhamo kwiConvyeer belt? Iyalawuleka na kwishift?

Not manageable (Ayilawuleki)		**Sometimes manageable** (Ngamanye amaxesha iyalawuleka)		**Always manageable** (Ngalo lonke ixesha iyalawuleka)
1	2	3	4	5

6. In the past 3 weeks, to what extent does working day shift/night shift cause you problems with:

Kwiiveki ezi-3 (ezintathu) ezidlulileyo, ukuyomelaphi uphangela iishift yasebusuku okanye emini, ukuzisa iingxaki kwezinto ezibhalwe ezantsi:

	Never		**Somewhat (Ngamaxesha athile)**		**Always (Rhoqo)**
(a) **Sleep**	1	2	3	4	5
(b) **Social life** (ubomi bokuhlala)	1	2	3	4	5
(c) **Domestic life** (ubomi basekhaya)	1	2	3	4	5
(d) **Work performance** (ukusebnza komsebenzi)	1	2	3	4	5

Modified Fatigue Impact Scale

Fatigue is a feeling of physical and mental tiredness and the lack of energy that many people experience from time to time. Generally, people who have been exposed to frequent physical and mentally demanding tasks experience stronger feelings of fatigue more often and with greater impact than others.

Ukudinwa kukudinwa emzimbeni nasengqondweni kunye nokunqongophala kwamandla abantu abaninzi abazifumanayo ngamaxesha athile. Ngokuqhelekileyo, abantu abaye baboniswa kwimisebenzi ehlala efuna umzimba kunye nengqondo bafumana iimvakalelo ezinamandla zokudinwa rhoqo kwaye zinempembelelo enkulu kunabanye.

Indicate how often the following statements applied to you while at work and compared to normal, during the past week:

Bonisa ukuba kukangaphi na ezi nkcazo zilandelayo zisebenza kuwe ngelixa usemsebenzini kwaye xa uthelekisa nesiqhelo, kwiveki ephelileyo:

	Never	Rarely	Sometimes	Often	Always
1. **I have been less alert**. Ndilumke kancinci	0	1	2	3	4
2. **I have had difficulty paying attention for long periods of time**. Kunzima uhlala ugxile ixesha elide	0	1	2	3	4
3. **I have been unable to think clearly.** Kuba nzima ucinga kakuhle	0	1	2	3	4
4. **I have been clumsy and uncoordinated.** Ndizibona ndibhidekile kwaye ingalungelelaniswa	0	1	2	3	4
5**. I have been forgetful.** Ndiye ndilibale izinto	0	1	2	3	4
6. **I have had to pace myself during my job tasks**.	0	1	2	3	4

Kufuneka ndithobe isantya xa ndisenza izinto zomsebenzi					
	Never	**Rarely**	**Sometimes**	**Often**	**Always**
7. **I have been less motivated to do anything that requires physical effort.** Ndiya ndiphelelwa inkuthazo yokwenza izinto ezdinga ukusebenzisa amandla	0	1	2	3	4
8. **I have been less motivated to participate in social activities.** Andibinawo umdla yokwenza imisebenzi yoluntu	0	1	2	3	4
9. **I have been limited in my ability to do things away from home**. Ndiye ndithintelwa ekwenzeni izinto kude nekhaya	0	1	2	3	4
10. **I have trouble maintaining physical effort for long periods**. Ndiyasokola ukugcina umgudu/amandla ixesha elide.	0	1	2	3	4
11. **I have had difficulty making decisions at work.** Ndiba nengxaki yokwenza izigqibo emsebenzini	0	1	2	3	4
12. **I have been less motivated to do anything that requires thinking**. Ndiya ndiphelelwa ngumdla yokwenza into ecingisa kakhulu	0	1	2	3	4
13. **My muscles have felt weak.** Izihluni zam zivakala buthathaka	0	1	2	3	4
14. **I have been physically uncomfortable**. Adikhululekanga ngokwasemzimbeni	0	1	2	3	4

15. **I have had trouble finishing tasks that require thinking.** Ndiyasokola ugqiba umsebenzi ekufuneka ndicinge kakuhle kuwo	0	1	2	3	4
	Never	**Rarely**	**Sometimes**	**Often**	**Always**
16. **I have had difficulty organizing my thoughts when doing things at home or at work.** Ndiyasokola ukulungelelanisa iingcinga xa kufuneka ndenze izinto ekhayeni okany emsebenzini	0	1	2	3	4
17. **I have been less able to complete tasks that require physical effort.** Andikhange ndikwazi ukugqiba imisebenzi efuna amandla.	0	1	2	3	4
18. **My thinking has been slowed down.** Indlela yocinga ayisafani nakuqhala, yehlise isantya	0	1	2	3	4
19. **I have had trouble concentrating.** Ndinengxaki yokugxila	0	1	2	3	4
20. **I have limited my physical activities during my free time.** Ndiye ndanciphisa imisebenzi yam yomzimba ngexesha lam lokuphumla	0	1	2	3	4
21. **I have needed to rest more often or for longer periods after work.** Ndifuna ukuphumla rhoqo okanye ixesha elide	0	1	2	3	4

Karolinska Sleepiness Scale (KSS)

The purpose of this scale, which will be asked at the end of your shift, is to measure your perceived level of sleepiness/alertness at a particular time during the day.

Please circle one number that best represents how you feel right now.

Injongo yesikali, eya kubuzwa ekupheleni kweshifti yakho, kukulinganisa inqanaba lakho lokulala / ukuphaphama ngexesha elithile emini.

Cela ufake isangqa kwi nana elimele ukuba uziva njani ngalo mzuzu.

Extremely alert (Ulumke kakhulu)	1
Very alert (Iphaphile kakhulu)	2
Alert (Phaphile)	3
Rather alert	4
Neither alert nor sleepy (Andiphaphanga kwaye andozeli)	5
Some signs of sleepiness (Ezinye iimpawu zobuthongo)	6
Sleepy, but no effort to keep awake (Ndilele, kodwa akukho nzame zokuhlala uthe qwa)	7
Sleepy, but some effort to keep awake	8
Very sleepy, great effort to keep awake, fighting sleep (Ukulala kakhulu, umzamo omkhulu wokuhlala uphaphile, ukulwa nokulala)	9

END

Thank you for answering the questions! Your time and effort are greatly appreciated.

A.4: ENVIRONMENTAL AND WORK OUTPUT ASSESSMENT

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

Date: ______________________

Shift: DAY / NIGHT

Time: ______________________

<u>Workplace recordings</u>

Shift start time: ___________

Shift end time: ____________

Number of sorters in room 1: __________________

Number of sorters in room 2: __________________

Number of sorters in room 3: _________________

Number of crates of fruit offloaded at beginning of system:

ROOM 1 ______________ crates.

ROOM 2 ______________ crates.

ROOM 3 ______________ crates.

Number of rest breaks per session: __________

Length of shift break 1: _____________ minutes.

Length of shift break 2: ______________minutes.

Length of shift break 3: _______________minutes.

<u>Environmental recordings</u>

Temperature. Internal: _____________º (END OF SHIFT)

Noise. At sorters station 1: (MAX) _______________dBA

(MIN) ________________dBA

At sorters station 2: (MAX) ______________dBA

(MIN)_________________dBA

At sorters station 3: (MAX) ______________dBA

(MIN)_________________dBA

Lighting. At sorters station 1: ________________lux

At sorters station 2: ________________lux

At sorters station 3: ________________lux

APPENDIX B – ETHICAL DOCUMENTS

B.1: ETHICAL APPROVAL LETTER

RHODES UNIVERSITY
Where leaders learn

Rhodes University Human Research Ethics Committee
PO Box 94, Makhanda, 6140, South Africa
t: +27 (0) 46 603 7727
f: +27 (0) 46 603 8822
e: ethics-committee@ru.ac.za
NHREC Registration number: RC-241114-045

https://www.ru.ac.za/researchgateway/ethics/

1 April 2022

Ms Miriam Mattison

Email: M.Mattison@ru.ac.za

Review Reference: 2022-5389-6652

Dear Ms Miriam Mattison

Title: An investigation into fatigue prevalence amongst citrus packhouse sorters in the Eastern Cape province of South Africa

Researcher: Mr Harry Jack Robinson

Supervisors: Mrs Miriam Mattison,

This letter confirms that the above research proposal has been reviewed and **APPROVED** by the Rhodes University Human Research Ethics Committee (RU-HREC). Your Approval number is: 2022-5389-6652. In terms of the questionnaire Section 1, I still query the need for information on marital status and level of education. Perhaps it can be stressed to participants that not all of the demographic questions need to be answered?

Approval has been granted for 1 year. An annual progress report will be required in order to renew approval for an additional period. You will receive an email notifying you when the annual report is due.

Please ensure that the ethical standards committee is notified should any substantive change(s) be made, for whatever reason, during the research process. This includes changes in investigators. Please also ensure that a brief report is submitted to the ethics committee on the completion of the research. The purpose of this report is to indicate whether the research was conducted successfully, if any aspects could not be completed, or if any problems arose that the ethical standards committee should be aware of. If a thesis or dissertation arising from this research is submitted to the library's electronic theses and dissertations (ETD) repository, please notify the committee of the date of submission and/or any reference or cataloguing number allocated.

Sincerely,

Prof Arthur Webb

Chair: Rhodes University Human Research Ethics Committee, RU-HREC

cc: Ms Danielle de Vos - Ethics Coordinator

B.2: LETTER TO MANAGEMENT

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

Dear Manager/Supervisor

Re: Request to conduct research in Citrus Packhouse

I am Harry Robinson, a Masters student in the Human Kinetics and Ergonomics Department at Rhodes University in Makhanda (formally known as Grahamstown), and I am working on a research study titled: **An investigation into fatigue prevalence amongst citrus packhouse sorters in the Eastern Cape province in South Africa.**

To conduct this study, I want to ask your permission to access the sorters in your packhouse. Below is a summary of the purpose of my study, its procedures, and ethical considerations.

Background: The citrus industry in South Africa plays a significant role in domestic and global revenue and is governed by strict international regulations set on the fruit aimed at the export market to adhere to specifications in food safety. Citrus sorting remains one of the few tasks in this industry where fruit is inspected manually for quality defects (e.g., blemishes). It is therefore considered one of the most important duties within the packing process and factors that may influence the inspection process thus need to be minimized. It is hypothesized that one of these factors may be fatigue amongst sorters, particularly over the course of a shift and possibly even over a season. However, no articles were found in academic literature on human factors/ergonomics research studies in citrus packhouses in a South African context. This study will therefore follow sorters in the citrus packhouse(s) over the duration of a season to determine whether fatigue amongst these workers plays a role in their well-being and work performance. More specifically, the study will also focus on identifying the type of fatigue affecting workers (if at all), fluctuations over the harvesting season, as well as coping methods used by sorters to overcome the fatigue effects experienced.

I plan to visit numerous packhouses within the Sundays River Valley to assess as many citrus sorters as possible for this study so that the researcher can provide a realistic representation of this population. The benefit of this study is that it can provide evidence whether, or whether not, fatigue plays a significant role in workers' well-being and their work performance. If so, it would be the first step to developing a fatigue management system.

Procedures: This study consists of three parts. The first part entails an initial survey of the sorters to document demographic and work-related information. This survey should take only about 5 minutes to complete and will be completed at the beginning of the packing season.

The second phases consist of a survey conducted every three weeks from the start of the harvest season, through to the end of the harvest season in September. Participants are required to answer a few contextual questions about their current work situation, and general well-being as related to fatigue. The universal fatigue assessment that will be used in this survey is the Modified Fatigue Inventory Scale (MFIS) that requires the participants to answer 20 questions by circling a number from 0-4 that best describes how fatigue has/has not affected them over the past week. Furthermore, the Karolinska Sleepiness Scale (KSS), measures participants subjective sleepiness at a particular time during the day by circling a number between 1-10 which best reflects their level of alertness. The aim is to ask the KSS before the start of their shift, during their break, and at the end of their shift so that an average of their working shift can be calculated. The entire survey is designed to take no longer than 10 minutes and can be completed at a time that will not interrupt their work. In addition to asking the sorters questions, I will also keep a record of production-related information (e.g., day or night shift, number of citrus fruits processed in a shift) and environmental conditions (e.g., temperature, noise). This information will allow us to correlate the different factors that may influence fatigue responses. Finally, the third of the project will phase consist of a focus group discussion at the end of the season where participants will reflect on the past season and their perceptions of fatigue throughout the season. This will roughly take 30-45 minutes of their times.

I have attached the questionnaires/data collection sheets to this email for your perusal.

Ethical Considerations: There are minimal risks associated with participating in this study. Participants may potentially feel uncomfortable sharing sensitive information, while you as a manager maybe more concerned about reputational risk. To avoid and mitigate these risks, it is important to point out that all data and information gathered will be kept confidential and participants' identities and that of the packhouse/company will remain anonymous. Furthermore, since the aim of the study is to recognize general factors that may influence fatigue responses amongst sorters, all results will be collated and no individual worker or packhouse will be singled out or compared to another. Workers approached to participate in the study are under no obligation to complete this study and can withdraw from the study at any time without negative consequences. Feedback shall be given to packhouse management once the results have been complied and the thesis is submitted. Furthermore, feedback shall be given to the participants once data has been analysis and will be presented to them in the form of a pamphlet. The pamphlet will additionally provide them with information on fatigue in the work industry, the importance to prevent fatigue, and ways to alleviate the effects of fatigue.

This study has been approved by the Rhodes University Ethical Standards Committee (RUESC) (reference number: 2022-5389-6652) You may, on request, see the ethical clearance letter.

If you have any questions or concerns about this study, please contact myself, my supervisor, or the Rhodes University Ethics Coordinator.

Thank you for your interest in participating in this research.

Yours sincerely,

Harry Robinson
Student Researcher
Phone: 082-675 3515
Email: G17R5082@campus.ru.ac.za

Miriam Mattison
Supervisor
Phone: 082-319 4626
Email: m.mattison@ru.ac.za

RUESC Ethics Coordinator
Email: ethics-committee@ru.ac.za
Phone: 046-6037727

B.3: LETTER OF INFORMATION TO PARTICIPANTS

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

Dear participant,

My name is Harry Robinson, a Master of Science student in the Human Kinetics and Ergonomics Department of Rhodes University in Makhanda (formally known as Grahamstown). For my thesis I am conducting a research study titled: **An investigation into fatigue prevalence amongst citrus packhouse sorters in the Eastern Cape province of South Africa**.

This letter serves to ask you to participate in this research study. Below is a summary of the purpose of the study, its procedures, and ethical considerations.

Background: The citrus industry plays an important role in the South African economy, but strict international regulations are set on the fruit aimed at the export market to ensure specifications on food safety. Citrus sorting remains one of the few tasks in this industry where fruit is inspected manually for quality defects (e.g., blemishes). It is therefore considered one of the most important duties within the citrus packing process and factors that may influence the inspection process thus need to be minimized. It is hypothesized that one of these factors may be fatigue amongst sorters, particularly over the course of a shift and possibly even a season. No articles were found in the academic literature on human factors/ergonomics research studies in citrus packhouses in a South Africa context. This study will therefore follow sorters in citrus packhouse(s) over the duration of a season to determine whether fatigue amongst citrus sorters plays a role in their well-being and work performance. More specifically, the study will also focus on identifying the type of fatigue, fluctuations in fatigue over the harvesting season, and coping methods used by citrus sorters to overcome the fatigue effects experienced.

Procedures: The researcher plans to visit numerous packhouses within the Sundays River Valley to assess as many citrus sorters as possible for this study. There are 3 phases to this study. Phase 1 will be a once-off survey that asks about demographic information (e.g., age, race, home language, marital status, health status, and highest level of education.) and work-related characteristics (e.g., position employed, number of years worked, training, and transport used for work). These questions will take about 5 minutes to answer. Phase 2 consists of a survey conducted every two weeks from the start of the harvest season, through to the end of the harvest season. This survey will ask you questions about your perceptions of fatigue that you may have experienced in the previous week, and how you coped with the fatigue. The universal fatigue assessment that will be used in this survey is the Modified Fatigue Inventory Scale (MFIS) that requires you to answer 20 questions by circling a number from 0-4 that best describes how fatigue has/has not affected you over the past week. Furthermore, the Karolinska Sleepiness Scale (KSS), measures your subjective sleepiness at a particular time during the day. On the scale you will circle a number 1-10 which best reflects your level of alertness. The KSS will be asked at the beginning of your shift, during your break, and at the end of your shift. This entire survey should take you about 10 minutes to answer. The third and last phase of the study is a focus group interview which will be conducted at the end of the season. In this interview you and other participants will reflect on your perceived feelings of fatigue and its impact on work performance over the course of the past season.

Risks and benefits: There are minimal risks associated with participating in this study. You may potentially feel uncomfortable sharing sensitive information or feel you may jeopardize your position in the packhouse. This is due to the nature of some open-ended questions that will be asked in the focus group session. However, you do have the right to not respond to questions if they make you feel uncomfortable. Furthermore, the information you and other participants share will be kept confidential and your identity will remain anonymous. By using codes instead of names, the researcher can ensure anonymity for participants and the organization. The benefit of this study is that it can provide evidence whether, or whether not, fatigue plays a significant role in sorters' well-being and performance. If so, it would be the first step to developing interventions to manage system.

Anonymity and feedback: All information will be anonymous and at no time will your name or the name of the packhouse you work at be used within the reporting or documenting process. Since the aim is to recognize general factors that may influence fatigue responses, all results will be grouped together, and no individual responses are presented. You are under no obligation to complete this study and can withdraw from the study at any time without negative consequences. If you would prefer not to answer a question, you may leave it out. It is however very important that questions are answered honestly to allow for a genuine understanding of how fatigue may affect you and your work. Once the data have been collected and analyzed, the researcher will provide you with feedback on the findings, which will be presented to you in the form of a brochure. Additionally, the brochure will supply you with information on what fatigue is and ways to cope with the effects of fatigue.

This study has been approved by the Rhodes University Ethical Standards Committee (RUESC) (reference number: 5412). You may, on request, see the ethical clearance letter.

If you have questions or concerns about this study, please contact the researcher, his supervisor, or the Rhodes University Ethics Coordinator.

Thank you for your interest in participating in this research.

Yours sincerely,

Harry Robinson
Student Researcher
Email: G17R5082@campus.ru.ac.za
Phone: 082-675 3515

Miriam Mattison
Supervisor
Email: m.mattison@ru.ac.za
Phone: 082-319 4626

RUESC Ethics Coordinator
Email: ethics-committee@ru.ac.za
Phone: 046-603 7727

B.4: INFORMED CONSENT FORM

RHODES UNIVERSITY
Grahamstown • 6140 • South Africa

Informed Consent Form

Project title: An investigation in fatigue prevalence amongst citrus packhouse sorters in the Eastern Cape province of South Africa (***Mr Harry Robinson & Mrs Miriam Mattison***) from the Department of **Human Kinetics and Ergonomics**. Rhodes University has requested my permission to participate in the above-mentioned research project.

The nature and the purpose of the research project and of this informed consent declaration have been explained to me in a language that I understand. (*Die doel en oorsprong van hierdie navorsings projek en die ingeligte toestemmings deklerasie is aan my verduidelik in 'n taal wat ek kan verstaan)*

I am aware that *(Ek is bewus dat):*

1. The purpose of the research project is to investigate fatigue amongst citrus sorters working in packhouses over the duration of a harvest season. *(Die doel van hierdie navorings projek is om die moegheid van die Sitrus sorteerders wat in die pakhuise werk te ondersoek gedurende die oestyd tydperk te ondersoek)*.

2. The Rhodes University Ethics Committee has given ethical clearance to this research project, and I understand that I may request to see the ethical clearance letter. *(Die Rhodes Universiteit Etiek Komitee het etiese aanvaarding/goedkeuring vir hierdie navorsings projek, en Ek verstaan dat ek die etiek brief mag aanvra).*

3. By participating in this research project, I will be contributing towards one of the first ergonomic studies conducted on citrus sorters within a South African context. This research will give us insights into whether fatigue plays a significant role in sorting performance and the well-being of the workers. This study may therefore contribute to developing interventions to prevent fatigue if fatigue is found to influence the packhouse system. *(Deur deelteneem aan hierdie navorsings projek sal ek bydra tot die eerste ergonomiese studie wat uitgevoer is met sitrus sorteerders binne 'n Suid-Afrikaanse konteks. Hierdie navorsing sal insig verskaf in, of moegheid 'n groot rol in die sorterings bekwaamheid en algehele gesondheid van die werkers. Hierdie studie mag*

bydra tot die ontwikkeling van ingrypings om moegheid onder die werkers te verhoed as daar bevind word dat moegheid die pakhuis sisteme beinvloed).

4. I will participate in the project by completing a once-off survey that is aimed at documenting my demographic information and work characteristics. I will then be assessed every second week with a survey that will question my perceptions on fatigue that I have experienced in the past week. The fatigue assessment I will complete is the Modified Fatigue Impact Scale (MFIS) and the Karolinska Sleepiness Scale (KSS). Lastly, I will partake in a focus group at the end of the harvest season to reflect on my feelings of fatigue and the possible impact it had on work performance over the season. *(Ek sal deelneem in hierdie projek deur 'n 'once-off' vralys intevul wat gefokus is op die dokumentering van my demografiese informasie en my werks karakteristieke. Ek sal dan elke tweede week geassesseer word deur 'n vralys wat my perspektiewe van moegheid wat ek oor die laaste week ondervind het invul. Die moegheid assesseering wat ek sal invul is die Modified Fatigue Impact Scale (MFIS) en die Karolinska Sleepiness Scale (KSS). Laastens, sal ek deelneem aan 'n fokusgroep aan die einde van die oes seisoen om oor my gevoelens van moegheid en die moontlikheid dat dit 'n impak op my werksprestasie mag he, te reflekteer).*

5. My participation is entirely voluntary and should I at any stage wish to withdraw from participating further, I may do so without any negative consequences. *(My deelname is heeltemal vrywillig and sou ek verkies om in enige stadium te ontrek, mag ek so doen sonder enige negatiewe nagevolge)*.

6. I will answer all questions honestly to ensure an accurate statement of my experience. *(Ek sal al die vrae eerlik antwoord om te verseker dat die verklaring van my ervaring akkuraat is).*

7. I will not be compensated for participating in the research. *(Ek sal nie vergoed word vir my deelname in hierdie projek nie).*

8. I am aware that an audio recording will be made of the focus group discussion. *(Ek is bewus dat daar 'n stem opname van die fokusgroep gesprek gemaak sal word)*

9. There may be risks associated with my participation in the research. I am aware that: *(Daar is moontlike risikos vir my deelname in hierdie navorsings projek. Ek is bewus dat:)*

   a) Risks associated with my participation include, personal information and identity revealed. *(Risikos vir my deelname sluit in dat my persoonlike informasie en identiteit geopenbaar sal word).*
   b) Steps however have been taken to prevent these risks; only the student researcher (H Robinson) and his supervisor (M Mattison), and a

translator will be privy to this information during the process of data collection. Thereafter, any information will be deleted and the data that is to be stored by the principal investigator will not have any information revealing one's identity. *(Stappe sal geneem word om hierdie risikos te vermy; slegs die studente navorser (H Robinson) en sy toesighouer (M Mattison), en 'n vertaler sal privaatheid tot hierdie informasie gedurende die data opname proses he. Daarna sal enige informasie geskrap word en die data wat behoue gehou sal word deur die prinsipale navorser, geen informasie wat mens se identiteit bekend maak sal bevat nie).*

c) There is a very low chance of the risks occurring. *(Daar is 'n baie klein kans dat hierdie risioks sal plaasvind).*

10. The researcher intends publishing the research results in the form of a research report. However, confidentiality and anonymity of records will be maintained and that my name and identity will not be revealed to anyone who has not been involved in the conduct of the research. *(Die navorser beoog om die resultate van hierdie projek in die vorm van 'n navorsings verslag te publiseer. Alhoewel, konfidentialiteit en anonimiteit van die opgawe sal behoue bly en dat my naam en identiteit nie aan enige iemand wat nie deel was van hierdie projek, bekend gemaak sal word nie).*

11. The researcher will provide all participants with feedback. *(Die navorser sal terugvoering aan al die deelnemers verskaf).*

12. Any further questions that I might have concerning the research or my participation will be answered by either the student researcher or his supervisor. *(Enige verdere vrae wat ek mag he rakende hierdie navorsing of my deelname daarin sal beantwoord word deur die studente navorser of sy toesighouer).*

PARTICIPANT/ DEELNEMER

___________________________ ___________________________ _______________

(Print name) (Signed/onderteken) (Date)

PERSON ADMINISTRERING INFORMED CONSENT/ PERSOON WAT INGELIGTE TOESTEMMING ADMINITREER

___________________________ ___________________________ _______________

(Print name) (Signed/onderteken) (Date)

WITNESS/ GETUIE

(Print name) (Signed/onderteken) (Date)

APPENDIX C – STATISTICAL TABLES

C.1: DESCRIPTIVE STATISTICS

The data were transferred into the Statistica Software, *Model: Statistica 14 ©, TIBCO Software Inc. Version no. 14.0.0.15. USA (1984-2020)* for descriptive statistical analyses of demographic data, work-related information, and various fatigue assessment scores.

Table 16: Descriptive statistics of the demographic factors of all the participants.

	Descriptive Statistics (Sheet1 in COMPLETE RAW DATA)								
Variable	**Valid N**	Mean	Median	Frequency of Mode	Minimum	Maximum	Variance	Std.Dev.	Standard Error
GENDER	35	1,00	1,00	35	1,00	1,00	0,00	0,00	0,00
Age	34	38,12	36,50	3	24,00	59,00	77,08	8,78	1,51
Race	35	1,06	1,00	33	1,00	2,00	0,06	0,24	0,04
Martial status	35	1,23	1,00	29	1,00	3,00	0,30	0,55	0,09
Dependents: children	34	2,35	2,00	14	0,00	7,00	2,36	1,54	0,26
Dependents: Elderly	33	1,18	0,00	17	0,00	6,00	2,34	1,53	0,27
Education level	34	2,76	3,00	18	1,00	4,00	0,61	0,78	0,13
Chronic illness	35	1,69	2,00	22	1,00	3,00	0,28	0,53	0,09
Health status	35	4,20	4,00	20	3,00	5,00	0,40	0,63	0,11
Drink/smoke	35	2,29	2,00	23	1,00	4,00	0,45	0,67	0,11
Exercise	35	4,03	5,00	16	1,00	6,00	1,79	1,34	0,23

Table 17: Descriptive statistics of the work-related factors for all the participants.

	Descriptive Statistics (Sheet1 in COMPLETE RAW DATA)								
Variable	**Valid N**	Mean	Median	Minimum	Maximum	Variance	Std.Dev.	Coef.Var.	Standard Error
Work position	35	1,00	1,00	1,000	1,00	0,00	0,00	0,00	0,00
Yrs employed at PH	35	12,43	10,00	3,000	36,00	63,49	7,97	64,11	1,35
Yrs as sorter	35	9,29	6,00	2,000	36,00	73,45	8,57	92,29	1,45
Transport	35	1,00	1,00	1,000	1,00	0,00	0,00	0,00	0,00
Overtime?	34	1,00	1,00	1,000	1,00	0,00	0,00	0,00	0,00
Training course?	34	1,82	2,00	1,000	2,00	0,15	0,39	21,22	0,07
Second job?	34	1,94	2,00	1,000	2,00	0,06	0,24	12,30	0,04

Table 18: Descriptive statistics of the overall MFIS scores for all participants.

	Descriptive Statistics (Sheet1 in COMPLETE RAW DATA)									
Variable	**Valid N**	Mean	Median	Frequency of Mode	Minimum	Maximum	Variance	Std.Dev.	Coef.Var.	Standard Error
WK 1 MFIS TOTAL	28	36,61	38,50	2	6,00	68,00	201,14	14,18	38,74	2,68
WK 2 MFIS TOTAL	25	36,84	38,00	2	6,00	58,00	196,62	14,02	38,06	2,80
WK 3 MFIS TOTAL	28	41,77	43,00	3	10,00	74,00	222,58	14,92	35,72	2,82
WK 4 MFIS TOTAL	33	39,27	42,00	3	6,00	73,00	183,64	13,55	34,51	2,36
WK 5 MFIS TOTAL	32	40,41	42,00	3	8,00	72,00	174,06	13,19	32,65	2,33
WK 6 MFIS TOTAL	31	39,71	42,00	5	7,00	74,00	181,08	13,46	33,89	2,42

Table 19: Descriptive statistics of the MFIS scores for the day shift participants.

SHIFT=1
Descriptive Statistics (Spreadsheet in COMPLETE RAW DATA)

Variable	Valid N	Mean	Median	Minimum	Maximum	Variance	Std.Dev.	Coef.Var.	Standard Error
WK 1 MFIS TOTAL	17	40,18	43,00	13,00	68,00	193,15	13,90	34,59	3,371
WK 2 MFIS TOTAL	16	37,81	39,50	13,00	58,00	191,36	13,83	36,58	3,458
WK 3 MFIS TOTAL	15	45,33	44,00	21,00	73,00	198,67	14,09	31,09	3,639
WK 4 MFIS TOTAL	18	42,11	42,50	16,00	73,00	185,28	13,61	32,32	3,208
WK 5 MFIS TOTAL	16	41,63	42,00	12,00	72,00	226,65	15,05	36,17	3,764
WK 6 MFIS TOTAL	17	40,76	42,00	10,00	74,00	180,82	13,45	32,99	3,261

Table 20: Descriptive statistics of the MFIS scores for the night shift participants.

SHIFT=2
Descriptive Statistics (Spreadsheet in COMPLETE RAW DATA)

Variable	Valid N	Mean	Median	Minimum	Maximum	Variance	Std.Dev.	Coef.Var.	Standard Error
WK 1 MFIS TOTAL	11	31,09	33,00	6,00	54,00	178,89	13,38	43,02	4,033
WK 2 MFIS TOTAL	9	35,11	37,00	6,00	52,00	225,80	15,03	42,80	5,009
WK 3 MFIS TOTAL	13	37,65	33,00	10,00	74,00	234,81	15,32	40,70	4,250
WK 4 MFIS TOTAL	15	35,87	35,00	6,00	56,00	171,98	13,11	36,56	3,386
WK 5 MFIS TOTAL	16	39,19	40,00	8,00	55,00	129,90	11,40	29,08	2,849
WK 6 MFIS TOTAL	14	38,43	43,50	7,00	54,00	192,11	13,86	36,07	3,704

Table 21: Descriptive statistics of the physical MFIS subscale for all the participants.

Descriptive Statistics (Sheet1 in COMPLETE RAW DATA)

Variable	Valid N	Mean	Median	Minimum	Maximum	Variance	Std.Dev.	Coef.Var.	Standard Error
WK 1 PHYSICAL	35	16,15	16,00	2,00	31,00	37,71	6,14	38,03	1,04
WK 2 PHYSICAL	28	16,87	17,25	2,00	26,00	32,81	5,73	33,95	1,08
WK 3 PHYSICAL	30	18,90	18,95	6,00	32,00	39,49	6,28	33,26	1,15
WK 4 PHYSICAL	34	17,85	18,00	4,00	32,00	31,52	5,61	31,46	0,96
WK 5 PHYSICAL	34	18,82	19,00	6,00	32,00	34,63	5,89	31,27	1,01
WK 6 PHYSICAL	32	18,26	18,00	3,00	32,00	33,22	5,76	31,57	1,02

Table 22: Descriptive statistics of the cognitive MFIS subscale for all the participants.

Descriptive Statistics (Sheet1 in COMPLETE RAW DATA)

Variable	Valid N	Mean	Median	Minimum	Maximum	Variance	Std.Dev.	Coef.Var.	Standard Error
WK 1 COGNITIVE	30	17,62	18,00	2,00	38,00	73,41	8,57	48,62	1,56
WK 2 COGNITIVE	28	16,81	17,50	2,00	34,00	56,08	7,49	44,53	1,42
WK 3 COGNITIVE	30	18,50	18,25	4,00	36,00	49,48	7,03	38,02	1,28
WK 4 COGNITIVE	34	17,55	20,00	2,00	33,00	53,70	7,33	41,77	1,26
WK 5 COGNITIVE	33	17,94	19,00	2,00	32,00	40,50	6,36	35,48	1,11
WK 6 COGNITIVE	32	18,06	20,00	2,00	34,00	50,83	7,13	39,47	1,26

Table 23: Descriptive statistics of the psychosocial MFIS subscale for all the participants.

Variable	Descriptive Statistics (Sheet1 in COMPLETE RAW DATA)								
	Valid N	Mean	Median	Minimum	Maximum	Variance	Std.Dev.	Coef.Var.	Standard Error
WK 1 PSYCHOSO	35	3,09	3,00	0,00	7,00	3,55	1,88	61,02	0,32
WK 2 PSYCHOSO	30	3,66	4,00	1,00	8,00	2,42	1,55	42,52	0,28
WK 3 PSYCHOSO	31	4,00	4,00	0,00	7,00	2,55	1,60	39,92	0,29
WK 4 PSYCHOSO	34	3,88	4,00	0,00	8,00	2,71	1,65	42,46	0,28
WK 5 PSYCHOSO	34	3,88	4,00	0,00	8,00	2,77	1,67	42,93	0,29
WK 6 PSYCHOSO	32	3,65	4,00	0,00	8,00	2,87	1,70	46,51	0,30

Table 24: Descriptive statistics of the KSS scores for all the participants.

Variable	Descriptive Statistics (Sheet1 in COMPLETE RAW DATA)								
	Valid N	Mean	Median	Minimum	Maximum	Variance	Std.Dev.	Coef.Var.	Standard Error
WK 1 KSS	32	4,72	5,00	1,00	9,00	6,92	2,63	55,74	0,46
WK 2 KSS	31	5,15	6,00	1,00	9,00	5,49	2,34	45,53	0,42
WK 3 KSS	30	4,88	5,75	1,00	9,00	7,43	2,72	55,80	0,50
WK 4 KSS	34	5,21	6,00	1,00	9,00	6,11	2,47	47,47	0,42
WK 5 KSS	31	5,00	5,00	1,00	9,00	5,73	2,39	47,89	0,43
WK 6 KSS	30	5,33	6,00	1,00	9,00	6,92	2,63	49,32	0,48

Table 25: Descriptive statistics of the KSS scores for the day shift participants.

Variable	SHIFT=1 Descriptive Statistics (Spreadsheet in COMPLETE RAW DATA)								
	Valid N	Mean	Median	Minimum	Maximum	Variance	Std.Dev.	Coef.Var.	Standard Error
WK 1 KSS	17	4,41	5,00	1,00	9,00	7,88	2,81	63,64	0,68
WK 2 KSS	19	5,05	5,00	1,00	9,00	6,16	2,48	49,14	0,57
WK 3 KSS	16	5,13	5,75	1,00	9,00	8,55	2,92	57,05	0,73
WK 4 KSS	18	5,06	5,50	1,00	9,00	7,58	2,75	54,48	0,65
WK 5 KSS	16	4,75	5,00	1,00	9,00	7,80	2,79	58,80	0,70
WK 6 KSS	16	5,00	5,50	1,00	9,00	9,87	3,14	62,82	0,79

Table 26: Descriptive statistics of the KSS scores for the night shift participants.

Variable	SHIFT=2 Descriptive Statistics (Spreadsheet in COMPLETE RAW DATA)								
	Valid N	Mean	Median	Minimum	Maximum	Variance	Std.Dev.	Coef.Var.	Standard Error
WK 1 KSS	15	5,07	5,00	1,00	9,00	6,07	2,46	48,61	0,64
WK 2 KSS	12	5,29	6,00	1,00	7,00	4,84	2,20	41,57	0,64
WK 3 KSS	14	4,61	5,50	1,00	8,00	6,55	2,56	55,53	0,68
WK 4 KSS	16	5,38	6,00	1,00	9,00	4,78	2,19	40,69	0,55
WK 5 KSS	15	5,27	6,00	1,00	7,00	3,78	1,94	36,92	0,50
WK 6 KSS	14	5,71	6,00	2,00	9,00	3,76	1,94	33,93	0,52

Table 27: Descriptive statistics of the perceived work-pace for all the participants.

Variable	Valid N	Mean	Median	Minimum	Maximum	Variance	Std.Dev.	Coef.Var.	Standard Error
	Descriptive Statistics (Sheet1 in COMPLETE RAW DATA)								
WK 1 WORKPACE	33	3,58	3,00	1,00	5,00	1,25	1,12	31,29	0,19
WK 2 WORKPACE	32	3,55	3,00	2,00	5,00	0,93	0,96	27,12	0,17
WK 3 WORKPACE	32	3,38	3,00	1,00	5,00	0,97	0,98	29,15	0,17
WK 4 WORKPACE	34	3,38	3,00	1,00	5,00	0,91	0,95	28,20	0,16
WK 5 WORKPACE	33	3,30	3,00	1,00	5,00	1,47	1,21	36,68	0,21
WK 6 WORKPACE	33	3,21	3,00	1,00	5,00	1,05	1,02	31,86	0,18

Table 28: Descriptive statistics of the effect of shift work on the different lifestyle elements for all the participants (6. A= "Sleep", 6. B= Social life", 6. C= "Domestic life", 6. D= "Work performance").

Variable	Valid N	Mean	Median	Minimum	Maximum	Variance	Std.Dev.	Coef.Var.	Standard Error
	Descriptive Statistics (Sheet1 in COMPLETE RAW DATA)								
WK 1 6.A	32	2,41	3,00	1,00	4,00	1,02	1,01	42,04	0,18
WK 2 6.A	28	2,82	3,00	1,00	5,00	1,50	1,23	43,47	0,23
WK 3 6.A	26	2,75	3,00	1,00	5,00	1,47	1,21	44,01	0,24
WK 4 6.A	29	2,97	3,00	1,00	5,00	1,46	1,21	40,79	0,22
WK 5 6.A	30	2,60	3,00	1,00	5,00	1,28	1,13	43,56	0,21
WK 6 6.A	31	2,74	3,00	1,00	5,00	0,93	0,96	35,19	0,17
WK 1 6.B	27	2,41	3,00	1,00	5,00	1,56	1,25	51,85	0,24
WK 2 6.B	25	2,82	3,00	1,00	5,00	1,16	1,08	38,26	0,22
WK 3 6.B	23	2,96	3,00	1,00	5,00	1,04	1,02	34,55	0,21
WK 4 6.B	29	2,86	3,00	1,00	5,00	0,84	0,92	31,97	0,17
WK 5 6.B	30	2,60	3,00	1,00	5,00	0,94	0,97	37,25	0,18
WK 6 6.B	28	3,07	3,00	1,00	5,00	1,33	1,15	37,52	0,22
WK 1 6.C	27	2,96	3,00	1,00	5,00	1,96	1,40	47,25	0,27
WK 2 6.C	26	2,88	3,00	1,00	5,00	1,49	1,22	42,26	0,24
WK 3 6.C	25	2,92	3,00	1,00	5,00	1,51	1,23	42,14	0,25
WK 4 6.C	29	2,79	3,00	1,00	5,00	1,88	1,37	49,15	0,25
WK 5 6.C	28	3,04	3,00	1,00	5,00	0,92	0,96	31,68	0,18
WK 6 6.C	28	3,04	3,00	1,00	5,00	1,59	1,26	41,55	0,24
WK 1 6.D	29	3,10	3,00	1,00	5,00	1,95	1,40	45,03	0,26
WK 2 6.D	27	3,31	3,00	1,00	5,00	1,56	1,25	37,69	0,24
WK 3 6.D	24	2,81	3,00	1,00	5,00	1,41	1,19	42,20	0,24
WK 4 6.D	31	2,81	3,00	1,00	5,00	0,96	0,98	34,94	0,18
WK 5 6.D	30	2,83	3,00	1,00	5,00	1,32	1,15	40,49	0,21
WK 6 6.D	29	3,00	3,00	1,00	5,00	1,64	1,28	42,72	0,24

Table 29: Descriptive statistics of the environmental recordings over the study duration.

Variable	Valid N	Mean	Median	Minimum	Maximum	Variance	Std.Dev.	Coef.Var.	Standard Error
	Descriptive Statistics (Sheet1 in COMPLETE RAW DATA)								
WK 1 IN TEMP	2	14,65	14,65	12,80	16,50	6,85	2,62	17,86	1,85
WK 3 IN TEMP	2	16,75	16,75	16,30	17,20	0,41	0,64	3,80	0,45
WK 4 IN TEMP	2	16,20	16,20	14,20	18,20	8,00	2,83	17,46	2,00
WK 5 IN TEMP	3	19,80	19,80	18,00	21,60	3,24	1,80	9,09	1,04
WK 6 IN TEMP	3	21,33	20,40	18,10	25,50	14,34	3,79	17,75	2,19
WK 1 NOISE	2	87,60	87,60	86,60	88,60	2,00	1,41	1,61	1,00
WK 3 NOISE	2	85,00	85,00	84,00	86,00	2,00	1,41	1,66	1,00
WK 4 NOISE	3	85,27	85,20	84,90	85,70	0,16	0,40	0,47	0,23
WK 5 NOISE	3	85,23	85,60	84,30	85,80	0,66	0,81	0,96	0,47
WK 6 NOISE	3	85,00	85,70	83,60	85,70	1,47	1,21	1,43	0,70
WK 1 LIGHT	3	903,33	815,00	815,00	1080,00	23408,33	153,00	16,94	88,33
WK 3 LIGHT	2	1139,50	1139,50	984,00	1295,00	48360,50	219,91	19,30	155,50
WK4 LIGHT	3	746,33	737,50	681,50	820,00	4854,08	69,67	9,34	40,22
WK 5 LIGHT	3	656,50	717,50	416,00	836,00	46890,75	216,54	32,98	125,02
WK 6 LIGHT	3	679,00	799,00	418,00	820,00	51201,00	226,28	33,32	130,64

C.2: NORMALITY TESTING

The Shapiro-Wilks test for normality distribution was used to select the most appropriate tool for inferential statistics. Data sets with $p>0.05$ are normally distributed, whereas $p<0.05$ are regarded as not normally distributed.

Table 30: Normality table of the MFIS and KSS for the different shifts over the study duration.

	OVERALL MFIS	DAY SHIFT MFIS	NIGHT SHIFT MFIS	OVERALL KSS	DAY SHIFT KSS	NIGHT SHIFT KSS
WEEK 1	p= 0.988	p= 0.972	p= 0.985	p= 0.923	p= 0.903	p= 0.943
WEEK 2	p= 0.966	p= 0.958	p= 0.933	p= 0.938	p= 0.953	p= 0.773
WEEK 3	p= 0.970	p= 0.949	p= 0.911	p= 0.896	p= 0.888	p= 0.879
WEEK 4	p= 0.978	p= 0.962	p= 0.955	p= 0.923	p= 0.917	p= 0.902
WEEK 5	p= 0.933	p= 0.904	p= 0.903	p= 0.923	p= 0.916	p= 0.836
WEEK 6	p= 0.910	p= 0.884	p= 0.869	p= 0.910	p= 0.874	p= 0.910

C.3: INFERENTIAL STATISTICS

A General Linear Model analysis was used as to assess both normally and non-normally distributed data. Values that represent p<0.05 indicates significant effects and are highlighted in red. Factors with statistically significant results underwent Tukey post-hoc analyses.

Table 31: Inferential statistics of the MFIS between the different shifts and across weeks.

Effect	Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 29,4188 SS	Degr. of Freedom	MS	F	p
Intercept	203835,8	1	203835,8	235,5221	0,000000
SHIFT	1456,2	1	1456,2	1,6826	0,208649
Error	18174,7	21	865,5		
WEEKS	364,7	5	72,9	1,8353	0,112232
WEEKS*SHIFT	134,9	5	27,0	0,6791	0,640218
Error	4172,5	105	39,7		

Table 32: Inferential statistics of the physical subscale of the MFIS between the different shifts and across weeks.

Effect	Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 0,3632 SS	Degr. of Freedom	MS	F	p
Intercept	36,84604	1	36,84604	279,3405	0,000000
SHIFT	0,03834	1	0,03834	0,2907	0,594765
Error	3,16569	24	0,13190		
WEEKS	0,12009	5	0,02402	2,7665	0,021120
WEEKS*SHIFT	0,04291	5	0,00858	0,9885	0,427747
Error	1,04181	120	0,00868		

Table 33: Tukey post-hoc analysis of the physical subscale across the weeks.

Tukey HSD test; variable DV_1 (Sheet1 in COMPLETE RAW DATA)
Approximate Probabilities for Post Hoc Tests
Error: Within MSE = 10,947, df = 130,00

Cell No.	WEEKS	{1} 15,968	{2} 17,125	{3} 18,478	{4} 18,143	{5} 18,660	{6} 18,491
1	WK 1 PHYSICAL		0,793842	0,059598	0,151124	0,033362	0,057211
2	WK 2 PHYSICAL	0,793842		0,662786	0,868961	0,528546	0,653140
3	WK 3 PHYSICAL	0,059598	0,662786		0,999074	0,999954	1,000000
4	WK 4 PHYSICAL	0,151124	0,868961	0,999074		0,992686	0,998881
5	WK 5 PHYSICAL	0,033362	0,528546	0,999954	0,992686		0,999968
6	WK 6 PHYSICAL	0,057211	0,653140	1,000000	0,998881	0,999968	

Table 34: Inferential statistics of the cognitive subscale of the MFIS between the different shifts and across weeks.

Sigma-restricted parameterization
Effective hypothesis decomposition; Std. Error of Estimate: 0,3671

Effect	SS	Degr. of Freedom	MS	F	p
Intercept	25,88306	1	25,88306	192,0413	0,000000
SHIFT	0,39806	1	0,39806	2,9534	0,099738
Error	2,96513	22	0,13478		
WEEKS	0,03382	5	0,00676	1,2887	0,273947
WEEKS*SHIFT	0,03325	5	0,00665	1,2671	0,283297
Error	0,57728	110	0,00525		

Table 35: Inferential statistics of the psychosocial subscale of the MFIS between the different shifts and across weeks.

Sigma-restricted parameterization
Effective hypothesis decomposition; Std. Error of Estimate: 0,3509

Effect	SS	Degr. of Freedom	MS	F	p
Intercept	34,96540	1	34,96540	284,0477	0,000000
SHIFT	0,09040	1	0,09040	0,7344	0,399292
Error	3,20052	26	0,12310		
WEEKS	0,17913	5	0,03583	1,0592	0,386102
WEEKS*SHIFT	0,04520	5	0,00904	0,2673	0,930256
Error	4,39714	130	0,03382		

Table 36: Inferential statistics of the KSS between the different shifts and across weeks.

Effect	SS	Degr. of Freedom	MS	F	p
	Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 5,0520				
Intercept	4281,720	1	4281,720	167,7638	0,000000
SHIFT	12,584	1	12,584	0,4931	0,489049
Error	638,058	25	25,522		
WEEKS	5,049	5	1,010	0,3475	0,883069
WEEKS*SHIFT	4,999	5	1,000	0,3441	0,885235
Error	363,266	125	2,906		

Table 37: Inferential statistics of the perceived work-pace between the different shifts and across weeks.

Effect	SS	Degr. of Freedom	MS	F	p
	Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 1,8962				
Intercept	2084,216	1	2084,216	579,6746	0,000000
SHIFT	6,272	1	6,272	1,7444	0,197275
Error	100,674	28	3,595		
WEEKS	2,628	5	0,526	0,8514	0,515646
WEEKS*SHIFT	4,172	5	0,834	1,3518	0,246278
Error	86,423	140	0,617		

Table 38: Tukey post-hoc analysis of overall subscale scores over the weeks of the study.

Tukey HSD test; variable DV_1 (Sheet1 in COMPLETE RAW DATA)
Approximate Probabilities for Post Hoc Tests
Error: Within MSE = ,01946, df = 110,00

Cell No.	WEEKS	{1} ,48697	{2} ,53092	{3} ,43127	{4} ,46304	{5} ,46377	{6} ,48188
1	1		0,438204	0,185147	0,914553	0,924327	0,999943
2	2	0,438204		0,000872	0,055992	0,060596	0,313506
3	3	0,185147	0,000872		0,763250	0,745635	0,279144
4	4	0,914553	0,055992	0,763250		1,000000	0,968168
5	5	0,924327	0,060596	0,745635	1,000000		0,973146
6	6	0,999943	0,313506	0,279144	0,968168	0,973146	

** Overall subscales scores include the average scores for different subscales for the week.*

C.4: ENVIRONMENTAL AND WORK OUTPUT RECORDINGS

Table 39: Temperature recordings at the sorting table between the different shifts over weeks.

		DAY SHIFT G1	DAY SHIFT G2	NIGHT SHIFT
INTERNAL TEMPERATURE (°)	WEEK 1	16.5	N/A	12.8
	WEEK 2	N/A	N/A	N/A
	WEEK 3	16.3	17.2	N/A
	WEEK 4	18.2	N/A	14.2
	WEEK 5	19.8	21.6	18
	WEEK 6	20.4	25.5	18.1

Table 40: Light intensity recordings at the sorting table between the different shifts over weeks.

		DAY SHIFT G1	DAY SHIFT G2	NIGHT SHIFT
LIGHTING (Lux)	WEEK 1	815	815	1080
	WEEK 2	N/A	N/A	N/A
	WEEK 3	1295	N/A	984
	WEEK 4	681.5	820	737.5
	WEEK 5	416	717.5	836
	WEEK 6	418	820	799

Table 41: Noise levels recordings at the sorting table between the different shifts over weeks.

		DAY SHIFT G1	DAY SHIFT G2	NIGHT SHIFT
NOISE (dBA)	WEEK 1	N/A	86.6	88.6
	WEEK 2	N/A	N/A	N/A
	WEEK 3	84	N/A	86
	WEEK 4	84.9	85.2	85.7
	WEEK 5	85.8	85.6	84.3
	WEEK 6	85.7	85.7	83.6

Table 42: The number of sorters across the different shifts and rooms over the weeks.

	DAY SHIFT GROUP 1			DAY SHIFT GROUP 2		NIGHT SHIFT	
	ROOM 1	ROOM 2	ROOM 3	ROOM 1	ROOM 3	ROOM 1	ROOM 3
WEEK 1	17	24	24	17	24	19	21
WEEK 2	19	21	22	20	*	22	*
WEEK 3	5	22	19	*	*	18	18
WEEK 4	21	21	22	18	20	18	*
WEEK 5	22	20	19	19	20	19	16
WEEK 6	20	22	19	24	21	18	19

Table 43: The proposed number of crates offloaded for across the rooms per shift over the weeks.

	DAY SHIFT GROUP 1			DAY SHIFT GROUP 2		NIGHT SHIFT	
	ROOM 1	ROOM 2	ROOM 3	ROOM 1	ROOM 3	ROOM 1	ROOM 3
WEEK 1	*	*	*	387	232	292	289
WEEK 2	324	344	232	*	*	396	281
WEEK 3	252	252	252	*	*	364	261
WEEK 4	252	252	252	349	349	306	309
WEEK 5	394	401	297	436	312	443	372
WEEK 6	401	432	388	*	420	410	201

C.5: CORRELATIONS

Pearson's Product-Moment correlations analyses were conducted to determine any associations between the fatigue responses and the individual and work-related factors. Values that are highlighted in red indicate a significant relationship in a positive or negative direction.

Table 44: Pearson's Product-Movement Correlation analyses of the different demographic variables and their relationship with fatigue indicators. The values in red indicate a significant correlation.

	Correlations (MFIS SCORE in CORRELATION RESULTS FINAL) Marked correlations are significant at p < ,05000 N=150 (Casewise deletion of missing data)				
Variable	MFIS SCORE	KSS SCORE	PHYSICAL	COGNITIVE	PSYCHOSOCIAL
AGE	0,221562	0,206973	0,159713	0,248869	0,141364
#OF CHILDREN	0,187600	0,046008	0,177035	0,190767	0,123287
MARITIAL STAT	0,131981	0,048962	0,083405	0,146377	0,112769
EDUCATIONAL LEVEL	-0,214413	-0,052615	-0,188910	-0,228410	-0,195184
EXERCISE	-0,003797	0,093938	0,005063	-0,040096	0,001293
HEALTH STATUS	-0,382612	0,022695	-0,407051	-0,324032	-0,229042
YRS EMPLOYED	0,072998	0,206415	-0,011274	0,125159	0,064614
YRS SORTER	0,066237	0,258630	-0,000311	0,103101	0,051442
AVE SLEEP	-0,113877	-0,242380	-0,152692	-0,060278	-0,167669

Table 45: Pearson's Product-Movement Correlation analyses of the different fatigue indicators and their relationship with other fatigue indicators. The values in red indicate a significant correlation.

	Correlations (MFIS SCORE in CORRELATION RESULTS FINAL) Marked correlations are significant at p < ,05000 N=169 (Casewise deletion of missing data)				
Variable	MFIS SCORE	KSS SCORE	PHYSICAL	COGNITIVE	PSYCHOSOCIAL
MFIS SCORE	1,000000	0,147988	0,101904	0,948406	0,715608
KSS SCORE	0,147988	1,000000	0,005784	0,092219	0,142979
PHYSICAL	0,101904	0,005784	1,000000	0,074193	0,121378
COGNITIVE	0,948406	0,092219	0,074193	1,000000	0,655168
PSYCHOSOCIAL	0,715608	0,142979	0,121378	0,655168	1,000000

Table 46: Pearson's Product-Movement Correlation analyses of the different lifestyle elements affected by shiftwork and their relationship with fatigue indicators (6. A= "Sleep", 6. B= Social life", 6. C= "Domestic life", 6. D= "Work performance"). The values in red indicate a significant correlation.

Correlations (MFIS SCORE in CORRELATION RESULTS FINAL)
Marked correlations are significant at $p < ,05000$
N=130 (Casewise deletion of missing data)

Variable	MFIS SCORE	KSS SCORE	PHYSICAL	COGNITIVE	PSYCHOSOCIAL
6.A	0,382310	0,221667	0,344399	0,395638	0,370569
6.B	0,274146	0,195592	0,278896	0,225067	0,271375
6.C	0,252815	0,127683	0,209884	0,244514	0,294631
6.D	0,336416	0,081035	0,322557	0,299484	0,259731

Table 47: Pearson's Product-Movement Correlation analyses of the different environmental conditions and work-pace, and their relationship with fatigue indicators.

Correlations (MFIS SCORE in CORRELATION RESULTS FINAL)
Marked correlations are significant at $p < ,05000$
N=86 (Casewise deletion of missing data)

Variable	MFIS SCORE	KSS SCORE	PHYSICAL	COGNITIVE	PSYCHOSOCIAL
#CRATES/SORTER	-0,099710	0,036550	-0,109986	-0,095082	-0,109762
TEMP	0,132021	0,138533	-0,060754	0,155958	-0,010999
NOISE	-0,151373	0,036610	-0,095778	-0,142692	-0,037492
LIGHTING	-0,127061	0,077790	0,227902	-0,142621	-0,099518
WORKPACE	-0,439735	0,000252	-0,029058	-0,366492	-0,234185