Nativa, Sinop, v.5, n.2, p.145-150, mar./abr. 2017.
Pesquisas Agrárias e Ambientais
DOI: 10.5935/2318-7670.v05n02a11
http://www.ufmt.br/nativa

ISSN: 2318-7670

Ergonomic study of timber manual loading in forestry fomentation areas

Stanley SCHETTINO[1*], Luciano José MINETTE[2], Wanderson Lyrio BERMUDES[3], Silvio Sergio CAÇADOR[3], Amaury Paulo SOUZA[4]

[1] ICA - Instituto de Ciências Agrárias, Colegiado de Engenharia Florestal, UFMG, Montes Claros, MG, Brasil.
[2] Centro de Ciências Exatas e Tecnológicas, Departamento de Engenharia Elétrica e Produção, UFV, Viçosa, MG, Brasil.
[3] PPGCF - Programa de Pós-Graduação em Ciências Florestais, UFES, Jerônimo Monteiro, ES, Brasil.
[4] Centro de Ciências Agrárias, Departamento de Engenharia Florestal, UFV, Viçosa, MG, Brasil.
*E-mail: stanley.sst@hotmail.com

Recebido em setembro/2016; Aceito em dezembro/2016.

ABSTRACT: This study aimed to perform an ergonomic evaluation of the timber manual loading activity on rural properties, in order to quantify the risk of development of musculoskeletal injuries in the forestry workers and, from the standpoint of ergonomics, identify the existence of the labor precarious conditions. Data were collected in small forest properties, located in Minas Gerais, and 28 forest workers were sampled. For evaluation, the 3DSSPP™ software, from the University of Michigan, was used. The results showed that there is a great and imminent risk to the health of workers during the manual loading of short logs, regardless of the phase of the activity, outstanding the risk of injury to the joints of the upper limbs (wrists and shoulders), as well as the trunk and coxofemorals. The resulting injury risks, whatever the mass of the handled short logs is, are due to the combination of posture and handled load factors, generating compression forces on the L5-S1 disc of the vertebral column that can be six times greater than the recommended limit value. Thus, under an ergonomic approach, the activity is being developed in an extremely precarious manner, with consequent early professional disability and decreasing work life of the workers.

Keywords: worker's health, work conditions, forest harvesting.

Avaliação ergonômica do carregamento manual de madeira em áreas de fomento florestal

RESUMO: Este estudo teve como objetivo realizar uma avaliação ergonômica da atividade de carregamento manual da madeira nas propriedades rurais, a fim de quantificar o risco de desenvolvimento de lesões musculoesqueléticas nos trabalhadores florestais e, do ponto de vista da ergonomia, identificar a existência da precarização do trabalho. Os dados foram coletados em pequenas propriedades florestais, localizadas em Minas Gerais, e 28 trabalhadores florestais foram amostrados. Para a avaliação, o software 3DSSPP™ da Universidade de Michigan foi utilizado. Os resultados mostraram que há grande e iminente risco para a saúde dos trabalhadores durante o carregamento manual de toretes, independentemente da fase da atividade, sendo evidente o risco de prejuízo para as articulações dos membros superiores (punhos e ombros), bem como o tronco e coxofemorais. Os riscos de injúrias resultantes desta atividade, qualquer que seja a massa dos toretes manipulados, devem-se à combinação de postura e fatores de carga manuseada, gerando forças de compressão no disco L5-S1 da coluna vertebral, que pode ser seis vezes maior do que o limite recomendado valor. Assim, sob uma abordagem ergonômica, a atividade está sendo desenvolvida de forma extremamente precária, com consequente invalidez profissional precoce e diminuição da vida profissional dos trabalhadores.

Palavras-chave: saúde do trabalhador, condições de trabalho, colheita florestal.

1. INTRODUCTION

The Brazilian forest sector occupies a prominent position in the economy of the country and is growing at positive rates in the recent decades (IBÁ, 2016). For this growth to occur in a sustainable manner, the expansion of the forest base becomes necessary, targeting the supply of industries with increasing amounts of forest raw materials. This growing necessity, coupled with the difficulty of acquiring new areas next to industrial units, considering the land valuation and the restrictive impositions by the Public Power, has led the forestry sector companies to seek new alternatives for reforestation, considering that the sustainability and competitiveness of the Brazilian forest industry depend on the expansion of its forest base. One of these alternatives that has been widely used is the forest fomentation, especially in small and medium-sized rural properties, besides the acquisition of timber from independent producers (ROCHADELLI et al., 2008).

In another aspect, in order to ensure the sustainability of the forestry business, big forestry producers are simultaneously seeking to reduce production costs, increase the productivity of their systems, reduce the dependence of labor and the rates of accidents and occupational diseases. The most widely used alternative has been the mechanization of timber production activities, from the implementation of forests, passing through harvesting and timber loading into trucks (SANTOS et al., 2013). It follows that the mechanization of these forestry activities in Brazil, in almost all cases, use machines with high costs of acquisition, operation and maintenance and that are inaccessible to small and medium forestry producers in most cases. According to Alves (2007), the economic difficulties, especially the lack of financial resources by rural producers, were pointed as the factors that hinder the most the development of forestry fomentation programs in the studied areas, suggesting no difference in other regions of the country. Currently, with the worsening of global economic crises, this scenario remains the same (AQUINO, 2013).

This scenario leads to several situations on which human force is essential, mainly in lands with high declivities and lack of technologies for mechanization at compatible costs. For workers, such activities show high energy expenditure, repetitiveness and rates of work accidents in addition to the possibility of developing musculoskeletal disorders (SILVA et al., 2008; FIEDLER et al., 2011; GALEAZZI et al., 2012). Among these activities, the timber manual loading stands out, which is a forest harvesting step that aims to dispose the timber on trucks for its transport to intermediate storage yards or to the consumer units. This is referred to the activity performed by forestry workers that has lifting and load manual transport in questionable quantities from the perspective of the limits recommended by different national and international standards, often associated with inadequate postures and unique features such as: restricted accessibility and mobility, steep terrains, exposure to extreme weather conditions, poorly developed and consequently inadequate tools and low-skilled labor. These and other factors contribute to the development of work-related diseases and risks to the health and physical integrity of the workers, possibly contributing to the labor precarious conditions.

In general terms, the labor precarious conditions refers to a wide and varied set of changes in relation to the labor market, working conditions, qualification of workers and labor rights, in the context of the breakdown process of the Fordist development model and of emergence of a new productive pattern (SANTOS; BIAVASCHI, 2014). Precarious jobs are often characterized by extreme working hours, deficiencies in security, low salaries, greater expo-sure to risks and stressful conditions (ANTUNES, 2007).

The incidence of different musculoskeletal disorders has been caused by negligence on postures and handling of excessive loads during the working day, reducing productivity, increasing absenteeism and decreasing the quality of life of the involved workers (COUTO, 1996), representing one of the major risk factors of injuries to workers. The appearance of fatigue symptoms by physical overload depends on the effort made, work duration and individual conditions, such as health status, nutrition and conditioning due to the practice of the activity (FIEDLER et al., 2011). As fatigue increases, the pace of work, attention and quickness of reasoning are reduced, making the worker less productive and more subject to errors and accidents.

Moreover, when the worker adopts a forced posture for prolonged periods, there is an imminent risk of a mechanical overload, which can trigger algic states and strength imbalances, endangering thus the physical and psychological integrity of the worker (OJHA; KWATRA, 2011). According to Iida (2005), the goal of occupational biomechanics is to analyze the interactions associated with the human being and labor and the possible consequences that implies from the movements of the musculoskeletal system, studying the postures and applied forces.

In view of this scenario, this study aimed to perform a biomechanical evaluation of timber manual loading activity in rural properties, in order to identify the existence of job insecurity and to quantify the risk of development of musculoskeletal injuries in forestry workers involved in this activity.

2. MATERIALS AND METHODS

2.1. Sampling characterization

Data were collected in forest properties, which were eucalyptus timber producers and linked to a pulp producer company through forestry fomentation contracts, located in the regions of the Jequitinhonha/Mucuri and the middle Rio Doce valleys, Minas Gerais state, located between meridians 42º17’00” to 43º25’00” of Greenwich west longitude and the parallels 17º05’00” to 18º50’30” south of the equator line latitude. The altitude varies between 800 and 1,100 m. According to the Köppen climate classifica-tion, the prevailing weather in the region is Aw - savanna rainy tropical, with dry winter and maximum rainfall in the summer, and the rainy season occurs between October and March (TONELLO et al., 2006; NASCIMENTO et al., 2011). The sampling was performed in May 2016.

The sample covered 28 workers, all males with average age values of 20.4 years, weight of 75.1 kg and height of 1.68 m. All workers were informed about the objectives and methodology of the work, signing the Free and Clarified Consent Form therefore being in accordance with the Resolution nº 196/1996 of the Research Ethics Committee of the Ministry of Health. The workers performed eucalyptus timber manual loading, with short logs of 2.40 m long and individual mass ranging from 10 to 120 kg, obtained after the weighing of short logs of different dimensions.

In the region of the studied area, forests are cultivated with eucalyptus in stands of hybrid clones of different productivities (from 150 to 370 m^3/ha, with an average of 300 m^3/ha) in the first rotation regime with the harvest at 7 years of age, 3 x 2 m spacing on average.

With the Forest Inventory average values and using Excel software, all the parameters necessary for the development of this study were calculated, aiming to quantify the number of logs and their respective masses necessary for the loading of each truck.

2.2. Description of the activity

The manual loading is the timber boarding operation in the truck body without the use of machines, being performed in general by a team of four to six workers for each truck, remaining half of these on the floor and half on the truck (Figure 1). Each team spends an average of two hours to load each


Source: The authors.

Figure 1. Operation of eucalyptus timber manual loading.

Figura 1. Operação de carregamento manual de madeira de eucalipto.

truck and the goal is 4 trucks per team per day, from Monday through Friday.

The activity is carried out in four phases, with the first two on the ground, performed by the same worker and the following two on the body of the truck, performed by another worker, as follows:

- Phase 1 (F1) - A worker who is on the floor bends down to pick up the log, lifting it until the height of his waist.
- Phase 2 (F2) - Next, this same worker dislocates carrying the log until the side of the truck, when he will pass it on to the worker that is on the body of the same.
- Phase 3 (F3) - The worker who is on the truck gets the short log and stands over the load to move it until its deposition point on the load.
- Phase 4 (F4) - Then, this worker moves and deposits the short log on the load.

2.3. Biomechanical evaluation

The biomechanical evaluation was performed by three-dimensional analysis, through photos and footage of workers performing the activity in various postures. For each phase of the activity and from the freezing of movements, the angles formed in the joints (wrist, elbow, shoulder, trunk, coxofemorals, knee and ankle) were measured, besides the compression force on the disc between lumbar 5 and sacral 1 (L_5-S_1) vertebrae of the vertebral column. In association with the characteristics of the forces used, as magnitude and direction, the amount of hands used and anthropometric characteristics of height and weight of the studied population, the angles were used to perform the analysis, previously selecting the forced static postures and measuring the angles for insertion into the computer program of Three-dimensional Static Strength Prediction Program (3DSSPP™) Biomechanical Model, version 5.0.9, developed by the University of Michigan of the United States (UNIVERSITY OF MICHIGAN, 2013). Within each phase of the activity cycles, the representative postures were selected to be analyzed biomechanically.

The computer program provided the recommended load limit, which corresponds to the weight that over 99% of men and 75% of women in good health conditions can lift. This limit load induces a compression force of the order of 3,426.3 N (Newton) on the L_5-S_1 disc of the vertebral column, which can be tolerated by most young and healthy workers. This value is calculated by the sagittal plane lowback analysis report included in the program. Furthermore, having as reference from National Institute for Occupational Safety and Health - NIOSH guidelines, based on biomechanical studies.

Moreover, for each joint evaluated and in each mass class, the percentage of workers able to exert the activity without the development of musculoskeletal injuries was provided by the program, representing the harmful potential to workers at each phase of the activity.

3. RESULTS

From the Forest Inventory data and technical information about the activity, all the parameters to be used for determining the number of short logs required to compose each load and its distribution by mass class were determined, with the results shown in Table 1.

Having the distribution of the mass classes of short logs by load and after the determination of the typical positions of each phase of the activity, the results of the analysis of the forces applied at the various joints of workers are shown, with the percentages of capable for each of the analyzed joints and considering the different mass classes of short logs to be loaded manually (Table 2).

In relation to the intervertebral discs, considering the risk of compression of the L_5-S_1 disk, for each phases of the analyzed activity and considering the different weight classes of short logs, the results are showed in Table 3 and Figure 2.

4. DISCUSSION

The results show that there is a great and imminent risk to the health of the workers during the manual loading of short

Table 1. Parameters calculated from the Forest Inventory data and distribution of short logs by load, according to the weight classes.

Tabela 1. Parâmetros calculados a partir dos dados de Inventário Florestal e distribuição dos toretes por carga, de acordo com as classes de massa.

Parameter	Value	Average distribution of the short logs by load		
		Weight class (Kg)	Number of short logs (nº)	%
Productivity of the forests	300 m³/ha	10	215	33.6
Density of the population	1,333 trees/ha	20	210	32.8
Individual average volume	0.225 m³/tree	30	62	9.6
Average DAP	17.3 cm	40	26	4.1
Average comercial height	19.2 m	50	39	6.1
Wood specific weight [1/]	850 kg/m³	60	34	5.4
Average mass of the trees	191.3 kg/tree	70	25	3.8
Short logs lengh	2.40 m	80	13	2.0
Number of short logs per tree	8 short logs/tree	90	6	1.0
Load volume per truck	18 m³	100	5	0.8
Timber mass per load [2/]	15.3 t	110	3	0.5
Number of trees per load	80 trees	120	1	0.2
Number of short logs per load	640 short logs	Total	640	100.0

[1/] Green volume base at the moment of cut – the timber does not undergo drying in the field.

[2/] Considering the type of truck used in the regions of the study and respecting the Scale Law.

Table 2. Results of the biomechanical evaluation for the phases of timber manual loading activity, considering different weight classes of short logs.
Tabela 2. Resultado da avaliação biomecânica para as fases da atividade de carregamento manual de madeira, considerando diferentes classes de massa dos toretes

Phase	Typical posture	Articulation	Percentage of capables in the joints according to the weight classes (kg) of the handled short logs											
			10	20	30	40	50	60	70	80	90	100	110	120
F1		Wrists	96	72	26	3	0	0	0	0	0	0	0	0
		Elbows	100	98	85	53	19	3	0	0	0	0	0	0
		Sholders	100	100	99	98	94	85	72	54	35	19	9	3
		Trunk	98	95	90	82	70	56	42	28	17	9	4	2
		Coxofemorals	87	81	73	64	54	44	34	26	18	12	8	5
		Knees	99	99	99	99	99	99	99	97	94	90	84	76
		Ankles	100	100	100	100	99	99	98	96	93	90	85	79
F2		Wrists	97	80	39	8	1	0	0	0	0	0	0	0
		Elbows	100	99	95	80	52	23	7	1	0	0	0	0
		Sholders	99	85	39	6	0	0	0	0	0	0	0	0
		Trunk	90	74	50	25	10	3	0	0	0	0	0	0
		Coxofemorals	88	79	64	46	29	16	7	3	1	1	0	0
		Knees	99	92	70	35	11	2	0	0	0	0	0	0
		Ankles	100	99	94	80	55	28	10	2	0	0	0	0
F3		Wrists	98	88	59	23	5	0	0	0	0	0	0	0
		Elbows	100	99	94	78	50	21	6	1	0	0	0	0
		Sholders	100	97	84	53	20	4	0	0	0	0	0	0
		Trunk	86	60	29	8	1	0	0	0	0	0	0	0
		Coxofemorals	58	32	13	3	1	0	0	0	0	0	0	0
		Knees	100	99	89	52	13	1	0	0	0	0	0	0
		Ankles	95	76	41	12	2	0	0	0	0	0	0	0
F4		Wrists	98	82	44	22	4	0	0	0	0	0	0	0
		Elbows	100	99	93	93	93	92	84	72	56	39	24	13
		Sholders	100	99	94	24	3	0	0	0	0	0	0	0
		Trunk	99	99	97	87	77	63	48	33	20	11	5	2
		Coxofemorals	94	89	81	44	26	14	6	2	1	0	0	0
		Knees	95	95	95	95	95	95	95	95	95	95	95	95
		Ankles	98	98	98	98	98	98	98	98	98	98	98	98

Table 3. Values of compression on the L_5-S_1 vertebral disc, in Newtons (N), for each phase of the manual loading activity, considering the different weight classes of short logs.
Tabela 3. Valores de compressão sobre o disco vertebral L_5-S_1, em Newtons (N), para cada fase da atividade de carregamento manual, considerando as diferentes classes de massa de toretes.

Phase	Weight classes (kg) of the handled short logs											
	10	20	30	40	50	60	70	80	90	100	100	120
F1	2,516	3,153	3,753	4,318	4,848	5,435	5,811	6,434	7,237	8,040	8,844	9,647
F2	3,850	5,175	6,499	7,824	9,148	10,743	11,797	13,122	14,446	15,771	17,096	18,420
F3	4,058	5,347	6,619	7,874	9,114	10,339	11,549	12,745	13,926	15,094	16,248	17,389
F4	1,524	2,031	2,714	3,508	4,117	4,591	5,032	5,603	6,363	7,123	7,883	8,643

Obs.: The underlined values refer to loads below the maximum recommended limit, without risk of injury to the vertebral column. The others, above the recommended limit, present risk of injury.

logs, regardless of the phase of the activity. All of the evaluated joints showed, and greater or lesser extent, a decrease in the number of workers able to perform the activity without risk of injury to the joints, as seen an increase in the mass of the short logs handled. The risk of injury to the joints of the upper limbs (wrists and shoulders) as well as the trunk and coxofemorals are noteworthy. This observation meets the results presented by Schettino et al. (2015), when they concluded that the fact of workers to remain in asymmetric postures of the trunk and use the upper limbs in excess to handle and transport materials were responsible for the high incidence of back pain and injuries to the joints of the workers.

It is also worth considering the postures adopted and necessary for the development of the activities. When a particular posture is adopted or a movement is performed in the workplace, many muscles, ligaments and joints of the body are triggered. Thus, incorrect movements or postures will produce mechanical tension in the muscles, ligaments and joints, causing pain in the shoulders, wrists, back, neck and other parts of the musculoskeletal system (BRITTO et al., 2014).

Besides the immediate muscle fatigue, long-term effects of inadequate postures are numerous: overload imposed to the respiratory tract, oedema formation, varicose veins and joints problem, particularly in the vertebral column. Such conditions lead then to the sometimes non-explicitly refusal of the affected workers to workplaces on which their postural limitations are too strong (COUTO, 1996).

According to Piccoloto; Silveira (2008), various studies performed allow us to conclude that excessive static and repetitive efforts are related to an increased risk of: inflammation in joints due to mechanical stress; inflammation of the tendons or the ends of the tendons (tendonitis or tenosynovitis); inflammation of the tendon sheaths; chronic degenerative processes, of arthrosis type in the joints; painful muscle spasms

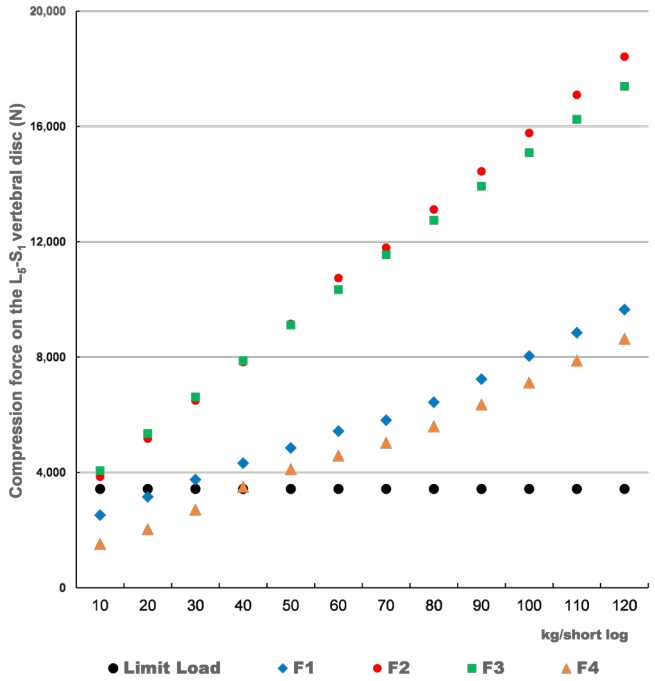

Figure 2. Variation of the compression force in the L_5-S_1 joint during the handling of short logs of different masses in the timber manual loading activity, in each phase of the activity, compared to the recommended load limit.

Figura 2. Variação da força de compressão na articulação L_5-S_1 durante o manuseio de toretes de diferentes massas na atividade de carregamento manual de madeira, em cada fase da atividade, em comparação com a carga limite recomendada.

(cramps) and; diseases of the intervertebral discs. The results presented in this study so far evidence that workers who perform the timber manual loading activity are directly exposed to the risk of development of such diseases and, even more, of the reduction of their useful age for work. This fact comes up when verifying the low age average of the workers performing the activity.

In relation to the intervertebral discs, considering the risk of compression of the L_5-S_1 disk, at some point all phases of the activities presented values above the maximum limit recommended by the 3DSSPP™ model, which is 3,426.3 N, indicating the high and constant risk of injury in the vertebral column joints (Table 3). As illustrated in Figure 2, phases 2 and 3 of the activity deserve negative highlight, which show higher values than the limit in all weight classes of short logs, reaching the impressive load of 18,420.0 N, about six times higher than that recommended as limit. In phase 1, the limit is exceeded with short logs of 25 kg mass, that is, any short log above this mass exposes the worker to injury risks; and in phase 3, this fact is with short logs of 37 kg. These amounts are due to the intrinsic characteristics of the activities, demanding postures with the sloping trunk and arms outstretched, generating excessive compression forces on the L_5-S_1 vertebral disc (MINETTE et al. 2015).

Functions which require repetitive flexion movements associated with trunk rotation and static and asymmetric working postures are also important risk factors for the occurrence of injuries to joints and vertebral column, according to the results presented. According to Minette et al. (2015), trunk flexion movements in large amplitudes constitute a risk factor for the vertebral column. The adoption of incorrect postures in forestry work, and also the handling of loads with weights above the maximum allowable limits, both sporadic and continually, as in the case of the workers in this study, cause pain, deform joints and cause arthritis, besides the possibility to incapacitate the worker (COUTO, 1996).

The results make clear the real the labor precarious conditions under the approach to ergonomics, regarding the risk of development of various musculoskeletal disorders, caudate by negligence in the postures and handling excessive loads during working hours, which have been greatly contributing to decrease productivity, increase absenteeism and decrease the quality of life of the workers involved in this activity, given the magnitude of the values found.

In fact, this seems to be a recurring fact in the Brazilian forest sector. By studying the postures of the workers involved in the semi-mechanized harvesting, Barbosa et al. (2014) concluded that it is necessary to research activity models with lower physical demand and the reduction in the weight of the logs to be handled is one of their recommendations, facing the possibility of generating disorders to the vertebral column of workers in a short-term.

Moreover, Minette et al. (2007) concluded that the handling of eucalyptus short logs during charcoal kilns loading requires physical effort of the worker above the recommended limit for cardiovascular capacity, besides the risk of compression of L_5-S_1 vertebral disc. In another study, Fiedler et al. (2015) by analyzing biomechanically the activity of eucalyptus timber manual loading and discharge for energy, affirmed that working conditions, postures and load handling are unsafe and that there is a risk of injury to workers involved in these activities, and the value of 4.7 kg had been recommended as the weight limit recommendable for short logs during manual loading.

This set of factors is sufficient to configure the precarious working conditions or deterioration because, according to Luce (2013), a violation of the value of the labor force, either because it is paid below its value, either because it is consumed by capital beyond the normal conditions. It's can lead to premature exhaustion of the force of the worker when increasing the journey or load of work causes a premature wear of the body and of the mind of the professional, and can also cause the "appropriation of future years of life and work of the worker". Thus, the author understands that the worker would be exposed to a form of labor exploitation that could invariably lead to emotional and physical wear; and therefore, the work would sicken the worker.

Finally, the evolution of the diseases acquired during the work causes them to become chronic, which causes impacts that overtake the physical health of the professional, because in many cases musculoskeletal disorders related to work cause sequelae that imply in successive work leaves, and provoke limitations to perform the same work activity which caused the illness, or even other daily activities and the permanent disability of the worker (MAENO, 2001).

5. CONCLUSIONS

The manner how the activity is organized and performed on rural properties, all workers have a high risk of injury development in all joints evaluated, besides the risk of serious injury to the vertebral column in all the activity phases, whatever the weight of short logs handled is.

From the standpoint of ergonomics and health of the worker, timber manual loading activity on rural properties is being extremely precariously developed, with the risk of developing musculoskeletal injuries in forestry workers involved in this activity being imminent and very high, with consequent early professional disability and reduction of his working life.

6. REFERENCES

ALVES, A. M. S. Dificuldades econômicas e ecológicas de programas de fomento florestal e a importância de cooperativas. **Sociedade & Natureza**, Uberlândia, v. 19, n. 1, p. 5-18, 2007.

ANTUNES, R. Dimensões da precarização estrutural do trabalho. In: FRANCO T.; DRUCK G. **A perda da razão social do trabalho**: terceirização e precarização. Bomtempo Editorial, 2007. p. 13-22.

AQUINO, S. L. Estratégias empresariais e efeitos locais: a integração de pequenos agricultores à indústria fabricante de papel e celulose. **Revista IDeAS**, Rio de Janeiro, v. 7, n. especial, p. 158-197, 2013.

BARBOSA, R. P.; FIEDLER, N. C.; CARMO, F. C. A.; MINETTE, L. J.; SILVA, E. N. Análise de posturas na colheita florestal semimecanizada em áreas declivosas. **Revista Árvore**, Viçosa, v. 38, n. 4, p. 733-738, 2014.

BRITTO, P. C.; LOPES, E. S.; LAAT, E. F.; FIEDLER, N. C. Avaliação biomecânica de trabalhadores de diferentes estaturas nas atividades de plantio e adubação florestal. **Scientia Forestalis**, Piracicaba, v. 42, n. 102, p. 191-196, 2014.

COUTO, H. A. **Ergonomia aplicada ao trabalho**. O manual técnico da máquina humana. Belo Horizonte: Ergo, 1996. v. 2. 383 p.

FIEDLER, N. C.; BARBOSA, R. P.; ANDREON, B. C.; GONÇALVES, S. B.; SILVA, E. N. Avaliação das posturas adotadas em operações florestais em áreas declivosas. **Floresta e Ambiente**, Seropédica, v. 18, n. 4, p. 402-409, 2011. http://dx.doi.org/ 10.4322/floram.2011.059

FIEDLER, N. C.; ALEXANDRE FILHO, P. C. R. T.; GONÇALVES, S. B.; CARMO, F. C. A.; LACHINI, E. Análise biomecânica da carga e descarga manual de madeira de eucalipto. **Nativa**, Sinop, v. 3, n. 3, p. 179-184, 2015. http://dx.doi.org/10.14583/2318-7670.v03n03a05

GALEAZZI, E. O.; DAL CONTE, M.; VIDMAR, M. F.; LEGUISAMO, C. P.; TOAZZA, L.; CHIESA, F. L. Avaliação da carga de trabalho físico baseada na frequência cardíaca em operadores de fornalhas. Revista **Saúde e Pesquisa**, Maringá, v. 5, n. 3, p. 605-610, 2012. http://dx.doi.org/10.17765/1983-1870.2012v5n3p%25p

IBÁ - Industria Brasileira de Árvores. **Relatório IBÁ 2016**. São Paulo: Pöyry Consultoria em Gestão e Negócios Ltda, 2016. 100 p.

IIDA I. **Ergonomia**: projeto e produção. 2.ed. São Paulo: Edgard Blücher, 2005. 632 p.

LUCE, M. S. Brasil: nova classe média ou novas formas de superexploração da classe trabalhadora? **Trab. Educ. Saúde**, Rio de Janeiro, v. 11 n. 1, p. 169-190, 2013. http://dx.doi.org/10.1590/S1981-77462013000100010

MAENO, M. ALMEIDA, I.; MARTINS, M. C. V.; TOLEDO, L. F.; PAPARELLI, R.; SILVA, J. A. P. **LER/DORT: dilemas, polêmicas e dúvidas**. Brasília: Ministério da Saúde, 2001. 24 p. (Série A. Normas e Manuais Técnicos, n.º 104).

MINETTE, L. J.; PIMENTA, A. S.; FARIA, M. M.; SOUZA, A. P.; SILVA, E. P.; FIEDLER, N. C. Avaliação da carga de trabalho físico e análise biomecânica de trabalhadores da carbonização em fornos tipo "rabo-quente". **Revista Árvore**, Viçosa, v. 31, n. 5, p. 853-858, 2007.

MINETTE, L. J.; SCHETTINO, S.; SOUZA, V. G. L.; DUARTE, C. L.; SOUZA, A. P. Avaliação biomecânica e da carga física de trabalho dos trabalhadores florestais em regiões montanhosas. **Scientia Forestalis**, Piracicaba, v. 43, n. 107, p. 541-550, 2015.

NASCIMENTO, A. C.; LEITE, A. M. P.; SOARES, T. S.; FREITAS, L. D. Avaliação técnica e econômica da colheita florestal com feller-buncher. **Cerne**, Lavras, v. 17, n. 1, p. 9-15, 2011.

OJHA, P.; KWATRA, S. Role of ergonomics in reduction of occupational health hazards in forestry. **Asian J. Home Sci.**, Lucknow Metro U.P. India ,v. 6, n 2, p. 302-307, 2011.

PICCOLOTO, D.; SILVEIRA, E. Prevalência de sintomas osteomusculares e fatores associados em trabalhadores de uma indústria metalúrgica de Canoas - RS. **Revista Ciência & Saúde Coletiva**, Rio de Janeiro, v. 13, p. 507-516, 2008.

ROCHADELLI, R.; MENDES, R. H.; SCHNEIDER, A. V.; MENON, C. R.; AUGUSTIN, C. R. Expansão florestal na região do Planalto Serrano Catarinense: uma perspectiva a partir do perfil socioeconômico dos proprietários rurais. **Floresta**, Curitiba, v. 38, n. 3, p. 459-464, 2008. http://dx.doi.org/10.5380/rf.v38i3. 12411

SANTOS, A. L.; BIAVASCHI, M. B. A terceirização no contexto da reconfiguração do capitalismo contemporâneo: a dinâmica da construção da Súmula nº 331 do TST. **Revista do Tribunal Superior do Trabalho**, São Paulo, v. 80, n. 3, p. 19-35, 2014.

SANTOS, P.H.A.; SOUZA, A.P.; MARZANO, F.L.C.; MINETTE, L.J. Produtividade e custos de extração de madeira de eucalipto com clambunck skidder. **Revista Árvore**, Viçosa, v. 37, n.3, p. 511-518, 2013.

SCHETTINO, S.; MINETTE, L. J.; SOUZA, A. P.; CAMPOS, J. C. C. Biomechanical evaluation of semi-mechanized activities of forest establishment in mountain regions of Brazil. In: AREZES, P. M. (org.). **Occupational Safety and Hygiene III**. CRC Press/Bakelma, 2015. p. 9-12.

SILVA, E. P.; SOUZA, A. P.; MINETTE, L. J.; BAETA, F. C.; VIEIRA, H. A. N. F. Avaliação biomecânica do trabalho de extração manual de madeira em áreas acidentadas. **Scientia Forestalis**, Piracicaba, v. 36, n. 79, p. 231-235, 2008.

TONELLO, K. C.; DIAS, H. C. T.; SOUZA, A. L.; RIBEIRO, C. A. A. S; LEITE, F. P. Morfometria da bacia hidrográfica da Cachoeira das Pombas, Guanhães - MG. **Revista Árvore**, Viçosa, v. 30, n. 5, p. 849-857, 2006.

UNIVERSITY OF MICHIGAN. **3D Static Strenght Predition ProgramTM. Version 5.0.9 - Users's manual**. Michigan: University of Michigan. 2013.