Ex vivo penetration of low-level laser light through equine skin and flexor tendons

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OBJECTIVE
To measure penetration efficiencies of low-level laser light energy through equine skin and to determine the fraction of laser energy absorbed by equine digital flexor tendons (superficial [SDFT] and deep [DDFT]).

SAMPLE
Samples of skin, SDFTs, and DDFTs from 1 metacarpal area of each of 19 equine cadavers.

PROCEDURES
A therapeutic laser with wavelength capabilities of 800 and 970 nm was used. The percentage of energy penetration for each wavelength was determined through skin before and after clipping and then shaving of hair, through shaved skin over SDFTs, and through shaved skin, SDFTs, and DDFTs (positioned in anatomically correct orientation). Influence of hair color; skin preparation, color, and thickness; and wavelength on energy penetration were assessed.

RESULTS
For haired skin, energy penetration was greatest for light-colored hair and least for dark-colored hair. Clipping or shaving of skin improved energy penetration. Light-colored skin allowed greatest energy penetration, followed by medium-colored skin and dark-colored skin. Greatest penetration of light-colored skin occurred with the 800-nm wavelength, whereas greatest penetration of medium- and dark-colored skin occurred with the 970-nm wavelength. As skin thickness increased, energy penetration of samples decreased. Only 1% to 20% and 0.1% to 4% of energy were absorbed by SDFTs and DDFTs, respectively, depending on skin color, skin thickness, and applied wavelength.

CONCLUSIONS AND CLINICAL RELEVANCE
Results indicated that most laser energy directed through equine skin was absorbed or scattered by the skin. To achieve delivery of energy doses known to positively affect cells in vitro to equine SDFTs and DDFTs, skin preparation, color, and thickness and applied wavelength must be considered. (*Am J Vet Res* 2016;77:991–999)

The effectiveness of LLLT for the treatment of musculoskeletal conditions such as tendon injuries or osteoarthritis is not universally accepted, as studies[1,2] have failed to unequivocally show clinical benefit. Reported positive effects include decreased inflammation,[3] decreased pain perception,[4,5] improvement of delayed wound healing,[6] and improvement in healing of injured deeper tissues such as tendons.[2] The cellular and molecular mechanisms underlying these effects have not been established. However, it is thought that absorption of light energy by cellular components triggers a chain of chemical reactions, resulting in altered cellular metabolism—a process termed photobiostimulation or photobiomodulation.[7,8] For example, LLLT increased ATP production and oxygen consumption in cells cultured in vitro,[9,10] which may be explained by absorption of laser light (wavelength, 600 to 1,000 nm) by cytochrome c,[11,12] a component of the mitochondrial electron transport chain. Further, absorption of light energy by cytochrome b and flavoproteins of the cell membrane-bound nicotinamide adenine dinucleotide phosphate (reduced form [NADPH]) oxidase complex[13] has been suggested to induce subtle changes in cells' redox potential by promoting the production of reactive oxygen species,[13–15] resulting in altered gene expression.[16]

Although in vitro investigations in other species have suggested possible benefits of LLLT in the treatment of tendon injuries, such as promotion of fibroblast proliferation,[17] increased decorin and type I collagen gene expression in tenofibrocytes,[17] and stimulation of tenocyte migration,[18] LLLT failed to improve the his-

ABBREVIATION
LLLT Low-level laser therapy