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Letter from the Editor

It is my pleasure to present this fourth issue of *Perpetua*. Contained within its pages is yet another sample of the exceptional undergraduate research presence at UAH, and to its organizers and participants, both student and faculty, *Perpetua* owes a debt of gratitude. Without the existence of this dedicated academic and creative community, *Perpetua* and its staff would not be able to offer their services in publishing undergraduate research and creating an official representation of undergraduate research at UAH.

While still a relatively young and developing student organization, this issue of *Perpetua* marks and celebrates two years of service to the UAH undergraduate research community. Since the release of our debut issue in the Fall 2016 semester, *Perpetua* has, as an organization, worked tirelessly to grow and evolve, taking on more staff of increasingly diverse academic and personal backgrounds and optimizing our means and resources to produce the best possible representation of UAH undergraduate research in a timely, consistent manner. Furthermore, we look to promote the benefits and accomplishments of the UAH undergraduate research community to as many sources as possible, including the UAH student body, the greater Huntsville research and outreach community, and prospective UAH students.

First and foremost, *Perpetua* is an organization devoted to the students of UAH. The research and creative projects published by *Perpetua* have been conceived and completed independently by UAH undergraduate students. The *Perpetua* editorial staff is comprised entirely of UAH undergraduate students. We seek to empower students on either side of the publication process, and to inspire our readers in the pursuit of their academic and professional goals.

We hope to continue to serve the University of Alabama in Huntsville in these roles and many more in the future.

Sincerely,

James Shelton Editor-in-Chief *Perpetua*

Special Thanks

Perpetua is a collaborative effort and publication would be impossible without the support of numerous individuals and organizations across UAH and throughout the greater Huntsville research and outreach community. We offer special thanks to all who have contributed their time, expertise, financial support, and hard work to *Perpetua*. A few of our biggest contributors are recognized below.

We thank the Student Government Association for providing sufficient funding to print and distribute physical copies of this issue. We would also like to thank Dr. William Wilkerson and the UAH Honors College for their commitment to providing additional financial support to *Perpetua*.

Next, we would like to extend our thanks to the faculty advisors who have consistently provided exceptional insight and guidance to our editorial staff since our inception. We thank Dr. Gordon MacGregor of the Department of Biological Sciences and Dr. Hamsa Mahafza of the Department of Education for joining Perpetua as full-time faculty advisors and for the invaluable feedback and assistance they provide in the process.

Finally, we thank every UAH graduate student and faculty member who served as a reviewer for one of the manuscripts featured in this issue. Without such individuals volunteering their time and expertise, *Perpetua* would not be able to provide our services to the UAH community.

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New Jersey Urban Development

Identifying Optimal Regions within New Jersey's Pine Barren Forest for Urban Development Based on Wildfire Risk and the Wildland-Urban Interface Theory

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Abstract - Population growth in New Jersey has led to increased use of land for residential purposes in the wildland-urban interface (WUI) of the south-central Pinelands region. Due to this increase in human activity, coupled with local environmental conditions, local authorities are concerned about an increased possibility of wildfires that could damage both the area's infrastructure and ecosystem. To counteract this risk, it is necessary to develop methods for accurate wildfire assessment and mitigation efforts. This project partnered with the New Jersey Pinelands Commission (NJPC) to develop a Fire Risk Assessment Tool that identifies areas with high fire risk based on land cover characteristics. We incorporated vegetation indices derived from Landsat 8 Operational Land Imager (OLI) and Sentinel-2 Multi-Spectral Instrument (MSI). land-use classification derived from LANDFIRE data and elevation into a Fuzzy Logic model to generate a 30 x 30 m Fire Risk Assessment Map. The map was used to analyze fire susceptibility in the Pinelands WUI and to identify optimal areas for urban expansion. Fiftythree percent of the total area within the Pinelands WUI was classified as having a moderate fire risk, while high and extremely-high fire risk accounted for 13%. An estimated 200,000 acres of land with a low to moderate risk of fire were identified as areas that would be suitable for development. The results and maps produced will be used by the New Jersey Pinelands Commission to guide urban development planning and decision making.

I. Introduction

Background Information

The region where human infrastructure and natural vegetation are adjacent or interspersed with each other is known as wildland-urban interface (WUI) (Radeloff et al., 2005; Theobald & Romme, 2007; Stewart, Radeloff, & Hammer, 2007). The WUI areas are widely increasing across the United States (Stewart, Radeloff, Hammer & Hawbaker, 2003). New Jersey is one of the most densely populated states within the U.S., and in recent decades, migration to the state's Pinelands region has increased due to the desire for privacy, space, natural beauty, and recreational opportunities. With the expansion of the WUI, there is increasing fear of higher wildland fire frequency and the threat to life and property due to fire (Fox et al., 2015). As a result, the wildland fire policy is dedicated to fire prevention and preparedness projects primarily in the WUI region (USDA, 2002).

The Pinelands lie in the south-central portion of New Jersey, covering 22% of the state's total land at 1.1 million acres in Ocean, Atlantic, Cape May, Camden, Gloucester, Burlington, and Cumberland counties (Forman, 1998; Clark, Skowronski, Gallagher, Renninger, & Schäfer, 2012). The gently sloping terrain has a vegetative cover mainly consisting of pine and oak stands, including "pygmy" stands, or trees at approximately 11 feet or less in height (New Jersey Pinelands Commission, 2015). The soil of the Pinelands region is sandy and porous, allowing for rainwater to swiftly infiltrate and filter through the ground, leaving the surface in drier conditions (Clark et al., 2012). This low water retention capacity results in an increased susceptibility to wildfires (DeBano, 2000). In addition to high permeability, Pinelands soil is acidic so the litter on the forest floor does not readily decompose causing fuel load to accumulate (Ludlum, 1983). The Pinelands ecologically depend on natural occurrences of wildfire in order for seeds to begin germination, and thus wildfire is a naturally occurring phenomenon of the region. However, with the expansion of the WUI, there is increased concern about higher risk of forest fires due to the increase in human recreational activities and changes in vegetation (Cohen, 2000). Therefore, thorough measures for wildfire mitigation and preparation are crucial for the community and the agencies overseeing the Pinelands region.

New Jersey experiences approximately 1,500 forest fires annually (State of New Jersey Department of Environmental Protection, 2017). Since 2008, the New Jersey Pinelands Commission (NJPC) has collaborated with the New Jersey Forest Fire Service to improve wildfire mitigation planning and execution. This collaborative study targeted the high risk areas of Stafford and Barnegat municipalities in Ocean County. However, there is a need for more updated and widespread methods for risk analysis and wildfire mitigation throughout the region. This project studied the Pinelands region using data from January to December of 2017 to create a Fire Risk Assessment Tool and map using Fuzzy Logic modeling in ArcGIS. The variables used in the model include vegetation type, fuel load, soil moisture, topography, and housing density of the WUI. Studies in spatial analysis of forests and human activity indicate that "areas with dense clusters of buildings surrounded by forestland have the highest density of fire ignition" (Chas-Amil, 2013). Certain vegetation types are more susceptible to wildfire, requiring thorough analysis of vegetation cover. Considering the effect of topography on vegetation distribution, a higher risk of ignition is associated with lower elevation areas which tend to have abundant vegetation, and thus increased fuel load (Calviño-Cancela, 2017).

II. Project Partners & Objectives

We partnered with the NJPC, which oversees fire suppression and prevention within the New Jersey

Pineland Reserve. A Fire Risk Assessment Map for the Pinelands area was developed in 1981, but with the influx of development that has occurred over the past 40 years, updated maps are necessary for proper management. In efforts to obtain updated information on the fire risk potential, the NJPC performs expensive and time consuming field assessments of vegetative conditions. While government funding for wildfire suppression has increased, the cost of fire suppression due to changes in climatic conditions and urban growth has increased as well, limiting the NJPC's ability to consistently monitor wildfire risk within the area (USFS, 2007).

The objectives of this project included identifying optimal areas within the WUI for urban development and locating areas where fire mitigation efforts should be allocated. The end products developed in this project will allow the NJPC to examine and update existing policies to better accommodate the changing environment in the pinelands region as population growth continues to increase.



Pinelands Management Area

Study Area

Figure 1. New Jersey and Pinelands Management Areas

III. Methodology



Figure 2. Methodology for developing the fire risk in the New Jersey Pinelands

Data Acquisition

We incorporated Sentinel-2 MultiSpectral Instrument (MSI) and Landsat 8 Operational Land Imager (OLI) data into this project. We acquired Sentinel-2 MSI Level 1C cloud free data for the year 2017 (April - November) from the United States Geological Survey (USGS) GloVis data portal. This included four tiles, T18SWJ, T18SVJ, T18TVK, and T18TWK, of Copernicus Sentinel-2 data 2017 covering the study area each with 13 spectral band layers. The data has a spatial resolution of up to 10 meters and a revisit time of 5 days. We also acquired cloud free Landsat 8 OLI data for several months (Feb/Jun/Jul/Oct/Dec) throughout 2017 in order to have a more complete understanding of the vegetation in the study area during the year. The data acquired from Landsat 8 OLI has a spatial resolution of up to 30 meters and a revisit time of 16 days. The data were collected from the GloVis data portal for the path (14)/row (32, 33) corresponding to the study area of southern New Jersey. We then used these data to derive vegetation and soil moisture indices for each month.

We obtained the Digital Elevation Model (DEM) data derived from high quality light detection and ranging (LiDAR) for the study area from USGS in the National Map-3D Elevation Program (3DEP) Data portal. The elevation data has a high spatial resolution of 1/9 arc second (3.4 meters). The total of 72 tiles of elevation datasets covering the study area dated from 2006 to 2011.

Data Summary		
	Spatial Resolution	Temporal Resolution
Landsat 8 OLI	30 m	16 days
Sentinel-2 MSI	10 m	5 days
DEM	3.4 m (1/9 arc)	

Table 1. Summary of attributes of the acquired data

We acquired vegetation data from the USGS LANDFIRE (LF) data portal. These data provided existing vegetation incorporating 89 different vegetation types. Vegetation type classifications were primarily derived from NatureServe Ecological Systems classification, alliances of the U.S. National Vegetation Classification, the National Land Cover Database and LF specific types.

The NJPC provided us with the zoning and management area shapefiles for the Pinelands. These data contained the Pinelands WUI extent. Similarly, the New Jersey Forest Service provided shapefiles of ignition sources and fire history for the Pinelands. This data included point locations of ignition sources for approximately five thousand fires over a 10-year period from 2008 through 2017 in the study area. The ignition source dataset detailed the location, acreage burned, and year of the fire. From the United States Census Bureau Topologically Integrated Geographic Encoding and Referencing System (TIGER)/Line Shapefiles data portal, we obtained NJ Roadway Network shapefiles. This dataset depicted the primary and secondary roads throughout the study area.

Data Processing

We mosaicked the USGS 3DEP data together to cover southern New Jersey and then clipped by the study area boundary to obtain the elevation for the area. This elevation layer was further processed to derive other topographical variables such as slope and aspect in ArcGIS.

The Euclidean distance tool calculated the distance from roads using the primary and secondary road shapefile. This tool provided how far away one road in the study area lies from others, so as to depict the area between major crossing roads. Within the area between roads, we assumed an increasing risk of wildfire with increasing distance from these major roads. Hereby, fire susceptibility increases with distance from major roads.

Each band from four tiles of Sentinel-2 MSI data and two tiles of Landsat 8 OLI data were mosaicked and processed to derive a Normalized Difference Vegetation Index (NDVI) and Tasseled (TCW) Cap Wetness for the leaf-on (Apr/May/Jun/Jul/Aug) leaf-off and (Feb/Sep/Oct/Dec) periods. NDVI is a graphical indicator of vegetation presence/abundance and vegetation health; TCW provides an indication of vegetation albedo and moisture content, which are additionally informative about vegetation health of the study area. Leaf-On refers to the growing season of the region during the aforementioned months, whereas Leaf-Off refers to the time period in which growing is minimal to nonexistent and deciduous trees are bare of leaves. The two time periods accounted for variation in fuel load availability as deciduous forests lose their leaves during the winter months and thereby provide a greater fuel load to burn. During the summer when deciduous forests regain their leaves, the increase in fuel load at both the surface and canopy leads to higher fire risk. We chose to use NDVI to analyze vegetation because it reflects the vegetation condition and health for the area, while TCW is associated with vegetation and soil moisture. Since soil moisture, and vegetation cover and condition play significant roles in wildfire occurrence, these variables had critical implication for the study. For NDVI, red (RED) and near infrared (NIR) bands were used from each earth observation data in raster calculator using **Equation 1** (Rouse, Haas, Schell & Deering, 1974; Deering, 1975). Similarly, TCW was derived using **Equation 2** which incorporated BLUE, GREEN, RED, NIR, and Shortwave Infrared (SWIR) bands (Baig, Zhang, Shuai & Tong, 2014).

(1)
$$NDVI = (NIR - RED) / (NIR + RED)$$

(2) TCW = 0.1509(BLUE) + 0.1973(GREEN)+ 0.3279(RED) + 0.3406(NIR)- 0.7112(SWIR1)- 0.4572(SWIR2)

After the calculations of NDVI and TCW, the indices were clipped to the study area. Then NDVI and TCW data for leaf-on and leaf-off periods were averaged using the respective months for each period. This process resulted in four final NDVI and TCW layers, one for each earth observation (Landsat 8 and Sentinel-2) and each time period.

We reclassified the LANDFIRE vegetation type data from 89 to 12 land classes. These classes included open water, sparsely vegetated, developed, exotic herbaceous, exotic tree-shrub, grasslands, conifer-hardwood, riparian, agricultural land, hardwood, conifer, and conifer-hardwood. Then we aggregated these vegetation types and ranked each from 1 to 9 based on fire susceptibility (**Table 2**). All of the input layers were re-projected to the North America Albers Equal Area Conic coordinate system for further analysis.

Land Use Classification (In Order of Fire Susceptibility)
Conifer
Conifer-Hardwood
Hardwood
Grassland
Exotic Herbaceous/Exotic Tree-Shrub
Sparsely Vegetated/Agriculture
Riparian
Developed
Open Water/Quarries/Gravel Pits/ Roads/Barren

 Table 2. Land Use classifications from the LANDFIRE Vegetation Type dataset

Data Analysis

Fuzzy Logic uses the Fuzzy Membership to reclassify the data into values between 0 and 1 to which determine how the data impacts the associated Fuzzy Logic recognizes that risk. binary classifications of 0 and 1 are extreme cases, and there exist variations of the truth in between such extremes (for example, 0.45 as opposed to strictly 0 or 1). To ensure the proper Fuzzy Membership and midpoint (median) assignments, we examined the frequency of ignition sources occurring in several input variables, including NDVI, TCW, vegetation type, and elevation. Specifically, all of the layers were overlaid with ignition source point data to understand the relation between fire occurrences and the respective variable layers. We then identified the frequency of ignition sources occurring within a given range for each variable, and the range with the highest number of ignition sources was determined to be the midpoint for the variable. The analysis between the NDVI and ignition sources showed that a majority of ignition sources occurred at Sentinel-2 MSI's leaf-on NDVI value of 0.47, Sentinel-2 MSI's leaf-off NDVI value of 0.35, Landsat 8 OLI's leaf-on NDVI value of 0.70, and Landsat 8 OLI's leaf-off NDVI value of 0.58 (Figures A1-A4). These values were used as midpoints when assigning Fuzzy Membership. Similarly, the examination between the elevation and ignition sources showed that a majority of ignition sources occurred in the range of 10 - 30 meters above sea level, with a sharp decline in ignition sources as the maximum elevation exceeds 30 meters (Figure B1). This result is likely due to increased vegetation abundance in lower elevation areas, and thus an increased fuel load in these low-lying areas. As elevation increases and vegetation abundance decreases, the risk for ignition decreases.

We used the fuzzy memberships "Near" and "Linear" based on the relation of variables with ignition sources and expert opinion from NJPC (Table 3). The NDVI and elevation were assigned "Near" memberships, while TCW, vegetation types, and distance to roads were assigned "Linear" memberships as their relationship with ignition sources were directly proportional. The "Near" membership demonstrated that the NDVI and elevation had the highest risk of fire at the midpoint value, and the risk decreased as values deviated from the midpoint. For elevation, values closest to 20-30 meters had a high fire risk, with a sharply decreasing fire risk for higher or lower elevations. High fire risk was assigned to the low TCW values that correspond to very dry areas, and low fire risk was assigned to the high TCW values that correspond to areas rich in moisture. Vegetation types received the "Linear" membership considering the ranking of fire susceptibility for class, as was shown in Table 1. For example, conifer forests were properly designated as high fire risk area and open water/barren/roads as low fire risk area.

Variable	Data Source	Spatial Resolution	Temporal Resolution	Date Published	Fuzzy Membership
Elevation	NLCD 3DEP	3.4m	-	2006-2011	Near (29)
NDVI Leaf On	Landsat 8 OLI	30m	16 Days	2017	Near (0.7)
NDVI Leaf On	Sentinel-2 MSI	10m	5 Days	2017	Near (0.47)
NDVI Leaf Off	Landsat 8 OLI	30m	16 Days	2017	Near (0.58)
NDVI Leaf Off	Sentinel-2 MSI	10m	5 Days	2017	Near (0.35)
TCW Leaf On	Landsat 8 OLI	30m	16 Days	2017	Linear
TCW Leaf On	Sentinel-2 MSI	10m	5 Days	2017	Linear
TCW Leaf Off	Landsat 8 OLI	30m	16 Days	2017	Linear
TCW Leaf Off	Sentinel-2 MSI	10m	5 Days	2017	Linear
Vegetation Types	LANDFIRE	30m	-	2014	Linear
Distance from Roads	TIGER	Line	-	2017	Linear

Table 3. Variables, and their assigned Fuzzy Membership, that were incorporated into Fire Risk Assessment Map

Understanding how roads affect the wildfire risk was challenging given that it is assumed to have both positive and negative associations with fire risk. One of the most common ignition sources was cigarette butts being tossed from primary and secondary roads, landing in relatively dry shrubbery along road sides, and igniting. This would lead to the assumption that closeness to roads has a higher fire risk than being further away, but these types of fires are generally not likely to spread due to the ease of access and containment by fire services. On the contrary, the increase in distance from roads increases the difficulty for fire rescue workers to access and combat potential wildfires. Based on this concept, distance from roads was assigned a "Linear" membership, where areas farther away from the road had a higher fire risk than areas near roads.

With all the datasets assigned a Fuzzy membership, we used the Fuzzy Overlay tool in ArcMap to incorporate each dataset into the model. The model weighed each variable based on its fire risk susceptibility, as determined by the assigned fuzzy memberships. In the Fuzzy Overlay tool there are various overlay types or methods which combine the Fuzzy data layers based on a given set theory analysis for each method. We selected the Gamma function method as it is an algebraic product of the Sum and the Product functions, each raised to the power of gamma (ESRI, 2016). As a result, is it a compromise between the increasing effect of sum and the decreasing effect of Product. By incorporating all of the variables into the Fuzzy Overlay tool, a Fire Risk Assessment Map was generated for the study area. The final map produced had a scale of 0 to 1, with 0 being the lowest fire risk and 1 being the highest fire risk. We classified the scale into five equal intervals, extremely low, low, high, and moderate, extremely high. The ModelBuilder in AcGIS incorporated all of these variables and/or processes to develop a Fire Risk Assessment Tool for NJPC to generate updated fire risk maps in future.

We used the Fire Risk Assessment Map for analyzing the fire risk of the Pinelands WUI. Based on the needs of the NJPC, four categories of the Pinelands Management Area that are more capable of accommodating development were selected for this analysis. This Pinelands WUI included the regional growth areas, pinelands villages, pinelands towns, and rural development areas. We clipped the Fire Risk Assessment Map to the Pinelands WUI to analyze the different fire risk classifications within the area.

IV. Results & Discussion

Analysis of Results

The Fuzzy Logic Model generated a 30meter resolution Fire Risk Assessment Map for the year (**Figure 3**). Of the study area, 13% was classified at high and extremely high fire risk, while 52% was classified moderate fire risk, 20% at low fire risk, and 15% at extremely low fire risk. The extremely low fire risk areas included the open water, barren lands, mine gravel pits, roads, and some of the developed regions. The extremely high fire risk category included the pine barren forest, which lies mostly in the preservation area of Pinelands.



Figure 3. Fire Risk Assessment Map for southern New Jersey classified in five equal intervals from low to high (on a scale of 0 to 100 from the original scale of 0 to 1 used in the Fuzzy Overlay).

The analysis of Pineland WUI showed that all four regions have a majority of their areas in low and moderate fire risk (**Table 4**; **Figure 4**). The extremely high fire risk areas in the Pinelands WUI accounts for less than 0.5% of the total area.

Table 4. Fire risk analysis of the Pinelands WUI

Pinelands WUI	Total Area(acres)	Fire risk Area within Pinelands WUI (acres)				
		Extremely Low		Moderate	High	Extremely
		Low				High
Regional Growth Area	126028.9	25197.3	29767.5	59672.8	11284.3	107.0
Rural Development Area	125245.9	10789.9	17679.5	78170.1	18499.2	107.2
Pinelands Villages	26128.5	3069.5	4603.6	12295.1	6012.4	147.9
Pinelands Town	24524.3	5388.4	5707.1	10825.9	2579.8	23.1



Figure 4. Fire risk analysis of the regional growth area (a), Pinelands villages (b), Pinelands town (c), and rural development area (d) within the pinelands management area. This shows that less areas are under higher fire risk and more areas in low and moderate fire risk.

Future Work

In this paper we report the calibration of the Fire Risk Assessment model but not its validation. In the future, ignition source data from 2018 (and years following) can be overlaid with the Fire Risk Assessment Map to validate its accuracy in predicting areas of high and extremely high fire risk. The Pinelands WUI boundary data were from 2014, making the extent of the current Pinelands WUI unknown. A fire risk analysis of the Pinelands WUI should be updated once current WUI boundaries become available. Higher resolution climate data, and other edaphic or topographic variables can be incorporated to more accurately assess the wildfire risk of the Pinelands. As more updated data become available in the following years, the project partner can input it into the Fire Risk Assessment Tool and generate updated Fire Risk Assessment Maps. Moreover, the NJPC can utilize this fire risk analysis of the Pinelands WUI to identify areas within the Pinelands to expand urban development.

V. Conclusions

A majority of the Pinelands WUI lie in low and moderate fire risk zones, which are considered to be suitable areas for development. The areas in the high and extremely high fire risk zones primarily lie in the Pinelands Preservation Area. However, within the Pinelands Preservation Area development is not permitted.

The most recent fire risk analysis of the New Jersey Pinelands was conducted in 1981 by the NJPC. Given the 36 year time difference, we discovered discrepancies in fire risk between the 1981 map and

the newly generated 2017 map. The 2017 map displayed considerably more areas lying in moderate fire risk than the 1981 fire risk map. The latter map showed the majority of the Pinelands in moderate to extreme fire hazard zones, with moderate zones outlining the northwestern region of the Pinelands. In the 2017 map, the majority of the study area lies in moderate risk zones, with high and extreme fire risks in isolated areas of the Pinelands. Reasons for these discrepancies are uncertain, but it could be due to changes in vegetation cover of the Pinelands area, expansion of the roadway network, and perhaps the lack of data in 1981 displaying false levels of high fire risk.

As population in the region continues to grow the areas of each fire risk area may change, becoming more or less severe than in recent years. The NJPC can use the end products provided by this project for decision making in planning and developing areas within the Pinelands WUI. The Fire Risk Assessment Map will help the NJPC to target areas for increased wildfire mitigation and to determine areas most suitable for urban development based on low fire risk. Moreover, the project partner will be able to produce updated ire risk assessments maps by using the Fire Risk Assessment Tool as new data becomes available.

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Positional Differences in Body Composition Among Division II Female Collegiate Soccer Players

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Abstract - Soccer is a popular and growing sport that is played all over the world. The four positions in soccer include: forward, midfielder, defender, and goalkeeper. Training and performance levels vary per player and by the position played. Being a physically demanding sport, it is important to understand body anthropometric measurement composition and differences between different positions in soccer players. PURPOSE: To determine if there were body composition and anthropometric measurement differences between varying positions within a NCAA Division II collegiate female soccer team. METHODS: A 7-site skinfold body density measurement (abdominal, triceps, midaxillary, thigh, subscapular, and suprailiac), chest, waist circumference measure (Gulick-tape), and body mass index (kg/m2) was used to determine if there is a difference in body composition among female soccer players. RESULTS: No statistical differences were found for body mass index and body fat percentage among different positions; however, there was statistical significant difference found for waist circumference among the different positions. Mean waist circumference for forwards, midfielders, defenders, and goalies were respectively 68.7, 71.0, 70.3, and 80.1 cm. CONCLUSIONS: Training and rehabilitation protocols do not need to be modified based upon position played.

I. Introduction

Soccer is sport that continues to grow in popularity both in the United States and throughout the world. The game consists of one team trying to score a goal in the opponent's net. There are four positions in soccer: forwards, midfielders, defenders, and a goalkeeper (see Figure 1). Forwards cover the offensive portion of the field and are the playmakers on the field whose job is to score goals. Midfielders play on both the offensive and defensive sides of the field. There are two kinds of midfielders: outside and central. Outside midfielders cover from their own goal to the opposing goal trying to get the ball to the forwards. The central midfielders are divided between an offensive midfielder and a defensive midfielder. They have the same job as outside midfielders, to get the ball to the forwards, while also trying to stop the opposing team from getting to the defensive half of the field. Defenders cover the defensive half and their job is to stop the other team's forwards and/or midfielders from reaching their goal. Goalkeepers have a restricted area known as the penalty box, where they can use their hands to protect the goal from shots from opposing teams.



Figure 1. Positions in Soccer

Soccer is a physically demanding sport using both anaerobic and aerobic capacity; however, goalkeepers tend to have longer careers than field players because the demands of the game are not as high for goalkeepers (Martinez-Lagunas, Niessen, & Hartmann, 2014). The physical demands include: constant changing of direction, acceleration, deceleration, lateral movements, jumping, tackling, agility, etc. (Martinez- Lagunas et al., 2014). The different physical demands of each position selects for different types of players. For example, some professional teams have shown goalies as tending to be older than other players and forwards tending to be heavier than defenders. (Bloomfield, Polman, Butterly, & Donoghue, 2005).

Studies have been performed comparing female soccer players versus male soccer players with only a few female physiological aspects considered (Martinez-Lagunas et al., 2014). Other studies have been done comparing body composition with body mass index (BMI) in youth soccer players (Nikolaidis, 2012B) and semi-professional soccer players (Nikolaidis, 2012a). To our knowledge, no studies exist comparing positional BMI and waist circumference in female collegiate soccer players. Body mass index is a quick and well accepted way to calculate if there is any obesity risk, or possibility for underweight risk, in the participant. BMI can be misleading, because BMI doesn't differentiate between muscle mass, body fat, or bone mass. For example, if you have a muscular person (athlete or non-athlete) being tested, the results could show an obesity risk when in reality the person has a higher amount of skeletal muscle mass (Nikolaidis, 2012a). Despite these shortcomings, BMI is still a useful baseline measurement to screen health status, especially when followed up with further measurement ("Why use BMI?", 2016).

Body composition consists of fat mass and fat-free mass. Fat mass can hinder an athlete's performance. An excess of fat mass can increase the energy demands needed for the activity being performed (Fields, Merrigan, White, & Jones, 2018). Fat-free mass translates to the amount of muscle mass present (Fields et al., 2018). Having more fat-free mass compared to fat mass allows an athlete to increase production of force during exercises being performed (Fields et al., 2018). Monitoring of body composition throughout an athlete's career and during the season can help improve health and performance (Fields et al., 2018).

Waist circumference is a simple and quick measurement of body fat. It allows for a person to understand the body fat distribution between the waist and hip (Liguori, Ehrman, Riebe, & Magal, 2018). Waist circumference, like BMI, can be used as a reference for obesity and other health risks (Liguori et al., 2018). However, increased muscle mass has a limited impact on waist circumference, while fat increase almost always affects the waist. This makes waist circumference a more selective measure than BMI. The American College of Sports Medicine Exercise Testing and Prescription Guidelines support this, listing waist circumference as a more accurate tool than BMI when measuring visceral adiposity. (Liguori et al., 2018).

Body composition and anthropometric measurements provide vital input into the health and

level of fitness of athletes. Health-related fitness measures will allow players, coaches, strength and conditioning coaches, athletic trainers, and sports medicine staff the ability to better individualize training and rehabilitation protocols. Thus, the purpose of this study was to determine if there were any differences in body composition based on the position played by Division II female soccer players. Therefore, we hypothesized midfielders will have a lower percent body fat, lower BMI, and lower waist circumference compared to goalkeepers, defenders, and forwards. Furthermore, we hypothesize that defenders and forwards will have a lower percent body fat, lower BMI, and lower waist circumference when compared to goalkeepers. These hypotheses were made on the assumption that greater amounts of field covered will result in more running, and a lower resulting body fat. Information on physical characteristics of elite female soccer players could help create a starting point for further research into specific training needs of female soccer players of different positons. In addition, these results could expand the demographics of current research which focuses primarily on professional male soccer players to include female and younger aged athletes.

II. Methodology

Participants

The participants in the study were National Collegiate Athletic Association (NCAA) Division II collegiate female soccer players ranging from 18 to 25 years of age (Vargus, Kerr-Pritchett, Papadopoulous, & Bennet, 2013). We divided the participants based upon position: forward, midfielder, defender, and goalkeeper. A total of five forwards, five midfielders, five defenders, and two goalkeepers were recruited for the study. Inclusion criteria for participants included: current Division II collegiate soccer player and 18-25 years of age. Players were excluded if they had recently worked out, due to the potential for sweat to skew measurements. All willing participants signed an IRB approved consent form.

lics
$M\pm SD$
19.61 ± 1.04
163.33 ± 4.56
60.62 ± 7.17
23.01 ± 2.87
21.68 ± 4.61
71.18 ± 5.00

Note. Values are mean \pm standard deviation

Outcome Measures

Anthropometric Measures

Participant height and body mass were measured and recorded for participant characteristics and BMI calculations. Each participant stood on a scale to measure body mass to the nearest 0.01kg (Santos et al., 2013). The participant then stood on a stadiometer (SECA, California, USA) to measure height to the nearest 0.1cm (Santos et al., 2013). This information allowed for BMI to be calculated using body mass (kg) divided by height in meters squared (m2).

Body Fat Percentage

To calculate body fat percentage, a skinfold assessment was performed using a Lange skinfold caliper on the right side of the participant's body while they were in anatomical position. A seven-site skinfold was performed on the following sites: tricep, midaxillary, suprailiac, subscapular, abdominal, chest, and thigh (Liguori, Ehrman, Riebe, & Magal, 2018). The site being measured was pinched with the thumb and index finger, in an attempt to remove as much muscle from fat as possible, before placing the caliper one cm away from the site. Each measurement was taken halfway between the top and the bottom of the pinched skin. During the measurement, the skinfold was held until the caliper was removed, taking approximately two seconds to obtain the measurement and remove the calipers. The American College of Sports Medicine states measurements should be taken twice and be within two mm of the first measurement. If the second measurement is more than two mm, then a third measurement should be taken (Liguori, G., Ehrman, J. K., Riebe, D., & Magal, M., 2018). During the process, the research team rotated through the seven sites to allow the underlying fat to regain its normal thickness. Each measurement was duplicated, but if the two measurements had a difference of greater than two mm, a third measurement was taken. The average score for each site was used to determine overall body density. The body density for each participant was then placed into a formula for young females to determine overall body fat percentage. Skinfold testing was not conducted if the participant just worked out due to the sweat. Sweat does not allow the researcher to pinch the proper amount of skin due to a slippery surface which can skew the data.

Waist Circumference

The participant stood with arms to their side, feet together, and abdomen relaxed. A Gulick-tape measure (Creative Health Products, Michigan, USA) was used and brought to the same marking each time for the most accurate results. The tape was placed on the narrowest part of the torso, right above the umbilicus but below the xiphoid process. Waist circumference measurement was taken twice. If the difference between the two measurements was more than five mm, a third measurement was taken to increase reliability of measurements (Liguori, Ehrman, Riebe, & Magal, 2018).

Statistical Analysis

Data analysis was performed using the Statistical Package for Social Sciences version 24.0 (IBM, New York, USA). A one-way analysis of variance was used to compared BMI, body fat percentage, and waist circumference across the four positions. A Bonferroni post-hoc analysis was also used to detect position differences. Statistical significance was established at p < 0.05.

III. Results

Participant characteristics including age, height, body mass, BMI, body fat percentage, and waist circumference, are presented in Table 1. For positional breakdown of the average
standard deviation of BMI, body fat percentage, and waist circumference see Table 2 and Figure 2. The results showed no statistical differences in BMI of different players based upon position played (F 3,17 = 2.060, p = 0.152). Body fat percentage also neglected to show any significant differences between positions. (F 3,17 = 0.794, p = 0.518). However, the waist circumferences of players were significantly different between players of different positions (F 3,17 = 3.963, p = 0.031). The Bonferroni post-hoc test revealed individual differences in waist circumference specifically between players of forward and the goalie positions (p = 0.027).

Table 2. Positional Breakdown							
Position	BMI	Body Fat	Waist Circumference				
Forward	21.69 ± 2.20	19.11 ± 2.07	68.70 ± 3.15				
Midfield	23.42 ± 3.47	22.75 ± 4.77	71.04 ± 4.87				
Defender	22.26 ± 2.01	21.96 ± 4.62	70.25 ± 4.02				
Goalie	26.91 ± 1.14	24.16 ± 9.60	80.13 ± 2.65				

Note. Values are mean \pm *standard deviation*



Figure 2. Body composition and anthropometric measurement differences by position.

IV. Discussion

The purpose of this study was to determine if there were any differences in body composition based on the different positions played by Division II female players. Initially, midfielders soccer were hypothesized to have the lowest values in all three components; body mass index, body fat percentage, and waist circumference. The results did not support this hypothesis. In addition, defenders and forwards were expected to demonstrate lower values when compared to goalkeepers. The results also did not enough to fully support this hypothesis. However, forwards were found to have a significantly different waist circumference value than goalkeepers.

Body Mass Index

The mean body mass index for forwards, midfielders, defenders and goalies were respectively 21.7, 23.4, 22.3, and 26.9 kg/m2. According to previous research by Bloomfield, Polman, Butterly, and O'Donoghue (2005), BMI played a role within positions and league played. Their results showed goalkeepers having the highest BMI when compared to the other positions; midfielders have the lowest BMI when compared to the other positions (Bloomfield et al., 2005). However, this study included professional players who also had a significant age difference based on their position. All the players in the current study were of college age, because it was not a professional team. Therefore, the differences in BMI from previous studies could be a result of the age difference and not from training/performance differences. Furthermore, while Bloomfield's study demonstrated an overall difference in BMI related to position, the results were also split up by team and not every team showed significant BMI difference between positions. Therefore, while some previous studies have correlated position and BMI, it appears to be team-specific as to whether position affects BMI.

Body Fat Percentage

The mean body fat percentages for forwards, midfielders, defenders, and goalies were respectively 19.1, 22.75, 21.96, and 24,16 %. The differences between positions was not statistically significant. This is contrary to previous literature conducted by Davis, Brewer, and Atkin (1992), which demonstrated a significantly higher estimated body fat percentage in goalkeepers compared to other positions. However, no body fat percentage difference was shown amongst the other positions. The positional difference in body fat percentage from our study was not significant and was contrary to the findings of a previous research study performed by Davis et al. (1992). However, the study by Davis et al. (1992), included professional soccer teams as opposed to collegiate soccer players. Therefore, age difference between professional players could exaggerate the body fat percentage differences in previous studies. Our study demonstrates no difference in body fat percentage of collegiate players based upon position.

Previous literature has grouped body fat percentage and BMI measurements together. One study concluded that clubs who develop exercise training programs should start targeting optimal body mass and fat (Nikolaidis, 2012A). In a different study, Nikolaidis (2012B) noted that overweightness was affecting younger soccer players in France and Greece. The weight issue was due to increases in body mass from an unequal balance between nutrition and physical activity (2012B). Both of Nikolaidis' (2012A & 2012B) studies resulted in BMI accounting for a large portion of between-individual differences when looking at body fat percentage. Body mass index can be a good starting point for determining if a person is normal, overweight, or obese. When looking at BMI, body fat percentage needs to be taken into consideration for a more valid result.

Waist Circumference

Mean waist circumference for forwards, midfielders, defenders, and goalies were respectively 68.7, 71.0, 70.3, and 80.1 cm. The difference between forwards and goalkeepers with goalkeepers having the highest waist circumference. There is a lack of previous research in regards to waist circumference in relation to soccer position. However, the results of the study do support previous findings that goalkeepers tend to be physically built differently than players of other positions. Further research should be conducted to understand why only forwards and goalkeepers had a significant difference for waist circumference.

Limitations

This study is limited in including players from only one school. As a result, the information produced may only be relevant in soccer players who are trained according to a similar program. Furthermore, there was variability in number of years each participant had played soccer, both overall and specifically in college. Athletes who have been competing at a higher caliber, such as a professional team, for more years may have lower BMI, body fat percentage, or waist circumference. Years in college may result in either increased or decreased body mass depending on training and nutrition variables. Future research could repeat the study while controlling for years of experience. In addition, a skinfold assessment was used to measure body fat percentage for convenience of the study. While this method is useful in minimizing the time required of the research participants, it does not provide the amount of information that some other methods of measurement do. For future research, the use of a Dual-Energy X-Ray Absorptiometry to measure body composition between the positions could provide a more accurate reading.

Future Research

Future research should focus on better understanding the differences in body composition of goalkeepers and the factors that influence these differences. In order to do so, the aforementioned Dual-Energy X-Ray Absorptiometry measurement could be used. In addition to body composition, the measurement also provides feedback on bone density values. Future studies could also take measures to better control for variables other than position in order to produce more specific results. Involving a large number of subjects from various programs could help minimize the effect of individual variation. Furthermore, performing research on differences in body composition between players from various teams (possibly between NCAA Division I and NCAA Division II teams) as well as between players of different years (freshmen vs senior) could provide the information necessary to better control for these variables.

V. Conclusion

There were no statistically significant differences in BMI or body fat percentage between players of different soccer positions in this study. This could be due to cross-over in positions played by athletes on this specific team, uniform training despite player position, or similar calorie expenditure across all soccer positions. However, the study did demonstrate statistically significant difference in waist circumference between forwards and goalies. Differences in waist circumference indicate different fat distribution between the positions. Goalkeepers often perform quicker and less continuous movements than field players do. Therefore, their training needs are different than the other players. There are significantly fewer goalkeepers than field players in soccer, resulting in them often being excluded as research subjects in studies on soccer (Milanovi, Vuleta, & Šiši, 2012). Increased knowledge about why goalkeepers develop a different body build than other positions could help coaches develop more individualized conditioning for their position.

VI. Acknowledgements

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The Cytotoxic Effects of Essential Oils on Estrogen Receptor Positive MCF-7 Breast Cancer Cell Line

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Abstract - The estrogen receptor positive MCF-7 breast cancer cell line was exposed to 11 essential oils that were extracted from various plants. MTT assays were executed to determine the percentage of killed cells after essential oil exposure. Three oils possessed cytotoxic activity; they originated from the species Helichrvsum italicum (HEITEO), Juniperus communis (JUCOEO), and Picea mariana (PIMAEO). The acronyms are derived from the first two letters of the genus and species name, followed by "EO". HEITEO, JUCOEO, and PIMAEO produced percent kill values of 99.1%, 99.4% and 98.9% respectively at concentrations of 0.01 micrograms/microliter. An LC50 value was obtained for Picea mariana (PIMAEO) with a percent kill of 48.6% at а concentration of 0.000313 micrograms/microliter.

I. Introduction

Since ancient times, plants and herbs have played a large role in curing and treating various ailments. Breast cancer is not exempt from the benefits of plant-based treatment. By understanding the cancer cells' reactions to various essential oils – hydrophobic liquids extracted from plants through evaporation, distillation, and fractionation – new cancer treatments can be discovered. There are various forms of breast cancer that grow and function in different ways. To narrow the focus and widen understanding, this study was confined to a specific breast cancer line: MCF-7. Several essential oils were examined to determine their cytotoxic capability. The essential oils of interest originated from the species *Picea mariana*, *Helichrysum italicium* and *Juniperus communis*

MCF-7 Cell Line

The MCF-7 cells originate from a metastatic estrogen receptor positive human breast carcinoma. The cell line is dependent on estrogen to proliferate and function. The hormone activates growth and protein production within cancerous cells [1]. Since its development in 1970, the MCF-7 cell line has been a valuable tool in breast cancer research. The line has had an active part in several research initiatives, including the creation of estrogen receptor antibodies, the study of hormone resistance in breast carcinoma cells, and the use of antiestrogens and aromatase inhibitors to decrease cancerous cell growth [2].

MTT Assay

The MTT [3-(4,5-dimethylthiazol-2-yl)-2,5diphenyl-2H-tetrazolium bromide] assay is a colorimetric tool used to quantify the amount of living cells within a sample. Viable cells retain a functional mitochondrial oxidoreductase enzyme. These enzymes reduce the yellow MTT salt solution into purple formazan crystals, while at the same time oxidizing NADH into NAD⁺ (**Figure 1**). The light absorbance can be measured by a spectrophotometer at 540 nanometers. A higher absorbance correlates to a higher amount of cell viability [3].



Figure 1. MTT reduced to formazan.

Plant Species of Interest

Picea mariana

Picea mariana, commonly known as black spruce, is a coniferous plant native to North America [5]. In recent studies, *Picea mariana* bark has been shown to contain high concentrations of biologically active polyphenols such as flavanoids and stilbenes. Flavanoids such as taxifolin and mearnsetin give the species its intrinsic antioxidant and anti-inflammatory properties. The stilbenes trans-resveratrol and astringin give the plant its antimicrobial properties. Hot water extraction techniques have recently been used to improve the bark extraction process [6].

Helichrysum italicium

Helichrysum italicium is a woody plant from the family Asteracea and is native to the Mediterranean. It has high concentrations of flavanoid and terpene compounds that give the species an antiinflammatory and therapeutic effect. The plant extract has been successful in treating skin inflammation disorders and respiratory allergies [7].

Juniperus communis

Juniperus communis is a coniferous plant native to the Northern Hemisphere. It is commercially used as a constituent of spices and beverages within the food industry. The essential oil has been utilized to treat respiratory issues and has been known to exhibit antioxidant and anti-inflammatory properties. In a 2017 study, the essential oil of a plant belonging to the Juniperus genus exhibited cytotoxic activity against the lung cancer cell line A549 [8].

II. Materials and Methods

Thawing Cells

The MCF-7 cells were removed from liquid nitrogen preservation and placed in a water bath (37 °C) to thaw for approximately one minute. The vial was not completely submerged in the water to avoid contamination. Cells were removed from the vial and placed into a centrifuge tube.

Ten mL of 37 °C RPMI 1640 media supplemented with penicillin-streptomycin and 10% fetal bovine serum were added to the tube. The suspension was centrifuged for 2-3 minutes and the supernatant was aseptically suctioned from the tube. The cells were then carefully resuspended into the supplemented RPMI 1640 media. The cell suspension was gently pipetted evenly into two separate T-25 cm² flasks. Flasks were placed into a 5% CO₂ humidified incubator at 37 °C.

Cell Culture

The cells were cultured in growth media consisting of RPMI 1640 media supplemented with 100,000 units of penicillin and 10.0 mg streptomycin per liter of medium, 10 % fetal bovine serum, 15 mM of HEPES, and buffered with 26.7 mM NaHCO₃ to pH 7.35. The cells were grown at 37° C in a 5% CO₂ humidified incubator. The media was replaced every two days and cells were passaged on a weekly basis.



Figure 2. MCF-7 cells in culture.

Replacing Cell Media

Flasks were removed from incubator. Media was aspirated off with a sterilized canula. Growth media (5mL) was aseptically added to each flask. After loosening caps to allow for gas exchange, flasks were returned to 5% CO_2 humidified incubator.

Subculturing Cells

A trypsin-Hanks Balanced Salt Solution (HBSS) mixture was made in a 1:10 ratio (1ml of trypsin to 9mL HBSS). The media was sterilely removed from flasks and 5 mL of HBSS were added to each flask to wash out remaining serum, which contains a trypsin inhibitor. The flasks were then gently rocked, and the HBSS was removed. Trypsin-Hanks solution (5mL) was added to each flask. After one minute, approximately 4 mL of the solution aspirated. Flasks were returned to the incubator for 2 minutes in order to increase the proteolytic effects of trypsin. Flask were retrieved and growth media (5mL) was added to each flask. The cell solution from each flask was placed into a single tube. The mixture was centrifuged for approximately 3 minutes. The supernatant was removed, and the cells were resuspended in fresh RPMI 1640 growth media.

Trypan Blue (0.3 mL), NaCl (0.6mL) and cell suspension (0.1mL) were mixed together; the solution was then placed in hemocytometer chambers for counting. The viable cells (free of blue stain) were counted. The cells were then plated at a seeding density of 1.75×10^5 cells per T-25 flask, while the 96-well plates were seeded at a density of 1.2×10^4 cells per well.

Serial Dilution

For preliminary testing of essential oils, a concentration of 0.01% w/v was used. However, dose response assessments were performed for those essential oils that exhibited cytotoxic capabilities (percent kills above 75% with a standard deviation below 10). Prior to the MTT assay, a two-fold serial dilution was performed to obtain the varying concentrations of essential oil. Media (1980 µL) and pure essential oil (20 µL) were placed in a tube to produce a 0.01% concentration. The 0.01% solution $(1000\mu L)$ and media $(1000\mu L)$ were added to the same tube to produce a 0.005% concentration. This process continued for preparation of concentrations of 0.0025%, 0.00125 %, 0.000625 % and 0.000313%. For each essential oil, the various concentrations were added to quadruplicate wells.

Cytotoxicity Screening

After adding the essential oils to the plate, the cells were incubated for 48 hours. An MTT assay was performed after the incubation to determine and quantify the cytotoxic effect of the essential oils. To prepare the MTT solution, 0.05 g of MTT was dissolved in 10 mL of 10 mM phosphate buffered saline (PBS) solution, pH 7.4. This stock solution was sterile filtered with a syringe, wrapped in foil to protect it from light, and stored in a refrigerator if needed for later use. An MTT-media solution (1:10 ratio) was prepared. MTT (1.2mL) and media (10.8 mL) were pipetted into a tube and vortexed. Media was aspirated from the 96-well plate and 100µL of the MTT-media solution was micro-pipetted into each well. The plate was then placed into a 96-well plate reader at 540 nm to obtain a pre-incubation reading. The 96-well plate

was then returned to the incubator. After 3-4 hours, the media was then carefully suctioned from each well as not to disturb formazan crystals. PBS (100µL) was added to each well to dissolve the formazan crystals. The plate was returned to the incubator for 5-10 minutes and then vortexed at the lowest speed for approximately 2 minutes. The plate was again placed into the 96-well plate reader at 540 nm to obtain the post-incubation reading. The percent kill, percent viable, and the standard deviation of the percent kill were calculated by the computer program. Prereadings were subtracted from post-readings for each well and then averages for the sets of quadruplicates were calculated. The average absorbance for each set of wells was divided by the average absorbance for the DMSO control wells to determine the percent of viable cells. The percent kill is then equal to 100% minus percent viability.



Figure 3. Dissolved formazan crystals.

III. Results

 Table 1: Initial Cytotoxicity Screening

Extract/Con	mpound	Average A (540 nm)	Std. Dev. of A (540 nm)	% Viable	% Kill	Std. Dev. of % Kill
	Medium	0.252	0.067			
	DMSO	0.119	0.029	47.0	53.0	
	Tingenone	-0.114	0.020			
SASCEO 0.01%	A3-D3	0.013	0.026	54.7	45.3	11.36
HEITEO 0.01%	A4-D4	-0.077	0.005	16.0	84.0	2.08
JUCOEO 0.01%	A5-D5	-0.064	0.008	21.2	78.8	3.56
COMYEO 0.01%	A6-D6	-0.008	0.057	45.7	54.3	24.39
CIBEEO 0.01%	A7-D7	0.146	0.034	112.	-12.0	14.78
PECREO 0.01%	A8-D8	0.128	0.019	103.9	-3.9	8.37
ALVIEO 0.01%	A9-D9	0.137	0.024	107.9	-7.9	10.37
PIMAEO 0.01%	A10-D10	-0.078	0.004	15.6	84.4	1.84
PEGREO 0.01%	A11-D11	0.074	0.035	81.0	19.0	15.11
PECRCEO 0.01%	A12-D12	0.270	0.051	165.3	-65.3	21.85
SAOFEO 0.01%	ЕЗ-НЗ	0.103	0.019	93.3	6.7	8.23
Media	E4-H4	0.224	0.019	145.4	-45.4	8.18
Media	Е5-Н5	0.343	0.165	196.4	-96.4	71.02
Media	Е6-Н6	0.233	0.060	149.3	-49.3	25.90
Media	E7-H7	0.271	0.204	165.6	-65.6	87.65
Media	E8-H8	0.273	0.078	166.4	-66.4	33.36
Media	Е9-Н9	0.263	0.042	162.2	-62.2	18.11
Media	E10-H10	0.242	0.046	152.9	-52.9	19.91
Media	E11-H11	0.224	0.059	145.2	-45.2	25.44
Media	E12-H12	0.591	0.098	303.5	-203.5	42.28

Table 1 displays the percent kill, percent viable and standard deviation of the percent kill for several essential oils. Those oils with percent kills above 75% and standard deviations below 10 were chosen for LC_{50} determination.

Extract/Comp	oound	Average A (540 nm)	Std. Dev. of A (540 nm)	% Viable	% Kill	Std. Dev. of % Kill
	Medium	0.636	0.129			
	DMSO	0.625	0.108	98.2	1.8	
	Tingenone	-0.086	0.045			
HEITEO (0.01)	A3-D3	-0.079	0.014	1.0	99.1	2.04
HEITEO (0.005)	A4-D4	0.082	0.027	23.6	76.4	3.78
HEITEO (0.0025)	A5-D5	0.000	0.021	12.0	88.0	2.94
HEITEO (0.00125)	A6-D6	0.076	0.039	22.7	77.3	5.46
HEITEO (0.000625)	A7-D7	0.191	0.031	39.0	61.0	4.35
HEITEO (0.000313)	A8-D8	0.160	0.069	34.6	65.4	9.78
JUCOEO (0.01)	A9-D9	-0.081	0.022	0.6	99.4	3.07
JUCOEO (0.005)	A10-D10	0.167	0.067	35.6	64.5	9.45
JUCOEO (0.0025)	A11-D11	0.198	0.036	39.9	60.1	5.03
JUCOEO (0.00125)	A12-D12	0.417	0.131	70.8	29.2	18.49
JUCOEO (0.000625)	E3-H3	0.164	0.123	35.1	64.9	17.28
JUCOEO (0.000313)	E4-H4	0.038	0.045	17.5	82.6	6.33
PIMAEO (0.01)	E5-H5	-0.078	0.016	1.1	98.9	2.24
PIMAEO (0.005)	E6-H6	0.169	0.037	35.8	64.2	5.19
PIMAEO (0.0025)	E7-H7	0.058	0.046	20.2	79.8	6.44
PIMAEO (0.00125)	E8-H8	0.070	0.037	21.9	78.1	5.25
PIMAEO (0.000625)	Е9-Н9	0.170	0.095	35.9	64.1	13.43
PIMAEO (0.000313)	E10-H10	0.280	0.056	51.4	48.6	7.84
Media	E11-H11	0.376	0.040	65.0	35.0	5.68
Media	E12-H12	0.436	0.084	73.5	26.5	11.78

*The LC*₅₀ *value for Picea mariana was 0.000313 %. HEITEO produced a percent kill of 61% at a concentration of 0.000625%. JUCOEO produced a percent kill of 60.1% at a concentration of 0.0025%.*

IV. Discussion

Eleven essential oil fractions were tested against the MCF-7 breast cancer cell line. The results reveal that from the original eleven, only three essential oils exhibited cytotoxic capabilities. The cytotoxic effect was determined qualitatively and quantitatively. By comparing the appearance of the essential oil wells in the 96-well plate to the positive control (tingenone) and the negative controls (DMSO and media), the general cytotoxic ability of the oil can be speculated. For example, those wells with colorless media, similar to the well containing tingenone, can be inferred to be cytotoxic. However, to execute a quantitative analysis of cytotoxicity, the percent kill values for each essential oil were analyzed. For the initial reading, the three essential oils (HEITEO, JUCOEO, PIMAEO) at concentrations of 0.01% had percent kill values of 84.0%, 78.8 % and 84.4% respectively. Essential oils SASCEO and COMYEO had positive percent kill values of 45.3% and 54.3% respectively. However, these values were not large enough to warrant LC₅₀ analysis.

Serial dilutions were performed to execute a dose response assessment and determine an LC_{50} (Lethal Concentration₅₀) value, which is the concentration at which 50% of the cells are killed (**Table 2**). The LC_{50} of the essential oil reveals the potency of the oil and the concentration of the oil needed to produce a substantial effect. The LC_{50} value of PIMAEO was 0.000313 micrograms/microliter with a percent kill of 48.6%. LC_{50} values were not found for HEITEO and JUCOEO, however HEITEO produced a 61.0% kill at a concentration of 0.000625 micrograms/microliter and JUCOEO produced a 60.1% kill at a concentration of 0.0025 micrograms/microliter. The lack of a LC_{50} value could

point to the potency of the two essential oils. However, there is inconsistency within the data. HEITEO had a higher percent kill as the concentration decreased from 0.000625 to 0.000313. This could be due to improper serial dilution technique or insufficient mixing of essential oil and media. One can infer however, that the actual LC₅₀ value is lower than 0.000625 micrograms/microliter. JUCOEO produced a 60.1% and 29.2% kill at 0.0025 micrograms/microliter respectively. It can be inferred that the actual LC₅₀ is between these two concentrations.

For the cytotoxicity testing, JUCOEO had the highest percent kill, which supports the notion that it is the most cytotoxic. However, in the initial screening JUCOEO had the lowest percent kill among the three essential oils. Multiple MTT assays should be done in the future to confirm which oil is the most effective in killing cells.

The essential oils HEITEO, PIMAEO, and JUCOEO produced a cytotoxic effect on the MCF-7 cells. These three essential oils could be further fractionated into specific polyphenols components that could then be tested against the cells. This would determine the specific constituents in the oils that possess the cytotoxic effect. Also, it would be advantageous to test the oils against other breast cancer cell lines such as MDA-MB-231 and Hs578T. Another aspect that could be examined in future studies is the genotoxic effect that the essential oils have on the cell. This could be accomplished by analyzing the DNA of the cells after exposure to essential oils. DNA fragmentation could be observed by gel electrophoresis.

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Trade Openness and Economic Growth

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Abstract – The purpose of this paper is to analyze the relationship between trade openness and economic growth. A simple graphical illustration of the relevant variables is used to examine this relationship. Data is obtained from The Organization of Economic Cooperation and Development. Quarterly data from 1990 to 2017 is used for this research. The results suggest that the relationship between trade openness and economic growth is not straight forward. Additional analysis will have to be done to reach more definitive conclusions.

I. Introduction

Many theories exist on the relationship between economic indicators and growth rates. Many are similar to what Arthur Melvin Okun discovered in the 20th century. He speculated, and later proved, the inverse relationship between economic production and unemployment. The objective of the research presented here is to explore and explain the relationship between trade openness and economic growth.

Trade openness and economic growth is a topic that has been under scrutiny in the trade and growth literature. Theoretically, if trade is restricted, then growth is affected. This research addresses the relationship between the volume of trade and economic growth. Trade openness is defined as the share of exports and imports to GDP. This measure is then used to examine the effects on growth. For instance, Yanikka (2003) [6], conducted an empirical investigation of different trade openness levels across OECD and non-OECD countries. He finds that trade openness, defined in terms of trade shares, shows that export shares and import shares are positively correlated. Harrison (1996) [3] conducted a study using a different technique and concluded that trade openness is statistically significant in contributing to economic growth.

In this research, trade openness is measured by taking the value of goods and services exported and imported and dividing that by total GDP. Economic growth rates and trade openness are thought to be interdependent. This research intends to validate or disprove this conjecture.

II. Data and Methodology

The time period chosen for this study is from the first quarter of 1990 to the second quarter of 2017. A financial quarter is defined as a three-month period used to summarize and report statistics. For example, the first quarter of 2017 would be from January 1st to March 31st, the first three months of 2017, and would be denoted Q1 2017. This time period includes the crash of 2008 and the subsequent global meltdown, and bailout, of the financial systems of several major countries, this offers a unique perspective to explore these variables. The global recession, in many ways, mirrored the Great Depression, at least in the United States. Housing prices fell nationwide, unemployment rocketed upward, and the stock market shed nearly half its value in a year. The expansive period featured here enables us to observe growth rate data, and trade openness data for more than fifteen years before the crash of 2008 and almost ten years after. This provides sufficient time and data points to analyze trade and growth.

The Organization for Economic Cooperation and Developments (OECD) consists of 36 members and was founded in 1960. OECD collects and disseminates information on not only its members but some non-member countries as well. Data on exports of goods and services, and imports of goods and services used in this paper was obtained from the OECD databases [4].

III. Trade Openness and Growth Rates

Trade openness is calculated by dividing the value of goods and services, both exported and imported, by total GDP, as mentioned earlier. The higher the numerical value, the greater the trade openness. Calculating the openness of many countries and graphing them alongside growth rates will help determine if any patterns exist. Although simple, it allows for comparing data over a period of time.





Figures 1 and 2, above, are comparing the United States and Belgium, both OECD countries. Trade openness is indicated by the blue bars and growth rate by the orange. The Great Recession is clearly visible in 2008 where both economies' GDP fell by nearly 2%. Before and after 2008, the US had marginally, but consistently, higher growth rates.

However, Belgium has consistently had a far higher level of trade openness. These economies are comparable in that they are both western democracies. Perhaps a more insightful comparison might be between two countries who have little in common both culturally and economically. The following graphs are comparing India and Canada.





As **Figure 3** shows, India, a developing country, has had far higher growth rates. However, **Figure 4** shows that Canada, a developed country, has had far slower growth. What makes these two graphs interesting is that both countries have similar but different levels of trade openness. This contradicts the results of the United States and Belgium. Of all the countries listed India has the fastest growth followed by the US and/or Canada with Belgium in last. However, Belgium is the most open to trade followed by India, Canada, and the US. So far, the countries that have been graphed do not seem to show a clear pattern or correlation between growth rates and trade openness. Even though the crisis of 2008 is very

visible in both sets of data, the remarkable decline in trade openness and growth rates the years preceding and following the collapse do not show a clear trend.

Another possibility is to compare a basket of developed economies with slower growth, to a basket of developing economies with faster growth. We can then graph the growth rates of the two baskets. These graphs then can be compared to those same countries' trade openness level. If faster growth is correlated to trade openness, then it will be clearly visible. One possibility is that trade openness has an inverse relationship to growth that will also be clearly visible.





Above are **Figures 5 and 6**, graphs of trade openness and growth rates of a basket of developing countries. Both graphs feature the same countries, except those without complete data, for consistent results. The general trend for trade openness has been steadily increasing. The trend for growth rates has also been quite steady hovering around 2% with Brazil having steep fluctuations. There does not appear to be a clear direction for both variables. As the level of trade openness increases, growth rate neither appears to increase (a positive relationship) or decrease (a negative relationship).





Figures 7 and 8 illustrate trade openness and economic growth for developed countries. Japan, like Brazil, has experienced extreme swings in growth rates. The US has experienced relatively consistent growth, outside of 2008. Of all the developed countries listed the average growth rate is around 1%, significantly lower than developing countries, while trade openness is around 0.1 or 0.2.

According to all four graphs, comparing the basket of developed and developing countries, there appears to be no correlation between growth rates and trade openness. Poorer countries tend to have smaller levels of trade openness with larger growth rates. Wealthier countries tend to have higher levels of trade openness, with slower growth rates. This would stand to reason that there is an inverse relationship. However, the US has the lowest level of trade openness of the countries, but it also has average to higher growth rates. One clear trend does appear to exist. The general direction of either growth rate or trade openness may be upwards or downwards but in the event of a great recession like 2008, both statistics in developed and developing countries decrease at a dramatic rate.

IV. Conclusion

The objective of this research was to explore several key economic indicators and statistics in order to deduce comprehensive patterns in a meaningful and understandable manner. The key economic statistics explored in this report were trade openness, exports, imports, and growth rates.

Trade openness and economic growth were examined for several economies. A simple comparison of growth rate and trade openness did not yield a specific pattern. However, we cannot conclusively state that trade openness and growth are unrelated since the data covered a relatively smalltime period and other factors such as technology and trade policies for instance, were not included. Further detailed analysis will be needed to establish a definitive relationship.

In an attempt to establish a relationship between growth and trade, future research could define trade differently and utilize other statistical analysis to discern patterns. A possibility for more advanced analysis might be an econometric analysis of the data collected here. An econometric analysis might validate the conclusions presented here or discover a completely different relationship. Even though an econometric analysis might have been useful it was not used here. Due to the definition of trade openness and the content of this research, an econometric analysis would not have been appropriate.

These results match some academics while contradicting others. Anderson, Lill, and Ronald Babula [1] in "The Link Between Openness and Long-Run Economic Growth" found a positive relationship between growth and trade openness. However, this relationship, as they point out, is more concrete in developing countries. Ulasan, Biilent [5] in "Openness to International Trade and Economic Growth: A Cross Country Emperical Investigation" found a similar relationship to Lill and Babula but used a longer time frame than used in this research. The academic community is still torn on this debate and more research is necessary. This conclusion allows for the continuation of academic discussions regarding international economic principle and completes the intended task of this research report outlined in the opening paragraph.

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Effects of Various Ankle Braces on Skill Related Performance in Collegiate Volleyball Players

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Abstract - PURPOSE: To test the effects of ankle bracing (rigid and semi-rigid) on performance in collegiate volleyball players. METHODS: Thirteen female division II collegiate volleyball players (height = 179.95cm ± 3.42 ; weight $= 72.26 \pm 6.01$ kg) were randomly assigned to a bracing condition (rigid, semirigid, no brace) and completed 3 different performance assessment skills. The T2 Active Ankle brace (Akron, OH) was used for the rigid brace and an AS1 Pro laceup (Akron, OH) was used as the semi-rigid brace. Each participant performed a lower body power test, straight line speed test, and lateral movement speed test on three separate occasions. Lower body power was measured using a vertical jump test. Straight line speed was measured using a 20-yard sprint. Lateral movement speed was measured using a four-corner agility drill. RESULTS: There was no significant difference (p <.05) between bracing condition for vertical jump height, straight-line speed, or lateral movement speed. CONCLUSIONS: Implementation of bracing (either rigid or semi-rigid) as a preventative measure does not significantly affect performance in collegiate volleyball athletes.

I. Introduction

Volleyball is a popular sport that is played amongst several colleges affiliated with the National Collegiate Athletic Association (NCAA). Volleyball can be characterized as a sport involving high rates of jumping, sprinting, and lateral movements. Ankle sprains tend to happen in high-risk sports that are known for contact, a high amount of jumping, or indoor activities (Rosenbaum et al., 2005). Unsurprisingly, ankle sprains are by far the highest occurring volleyball injury, comprising nearly 32% of reported volleyball injuries (Reitmayer, 2017). Bracing is a reliable treatment option for recent ankle injuries as well as for the prevention of additional injuries in athletes with possible instabilities during sport activities. It is common for volleyball athletes to wear ankle braces at all times while playing and practicing (Rosenbaum et al., 2005; Shaw, Gribble, & Frye, 2008).

There are numerous types of ankle braces with different levels of ankle support that are worn by players, such as rigid and semi-rigid braces. Ankle braces can have a large impact on athletic performance, making the choice of ankle support a critical decision (Hume & Gerrard, 1998). Due to the different physical demands and movements between different positional players on the court, more rigid braces are widely accepted as an injury prevention measure. This is especially true for those who are involved in more explosive jumping, while the semirigid braces are known to benefit the defensive players who primarily perform lateral movements and sprints during the game. Ankle braces protect the ankle by restricting ankle range of motion (ROM) in static and dynamic conditions as well as other mechanisms that are not yet fully understood (Papadopoulos, Nicolopoulos, Anderson, Curran, & Athanasopoulos, 2005). Restricted ankle ROM may negatively affect performance in running and jumping activities, but it seems to be dependent upon the type of support tested (Hume & Gerrard, 1998). Although ankle bracing can protect from athletic injury and impact athletic performance, it is not known whether braces have the potential to hinder certain abilities of a volleyball athlete (Shaw, Gribble, & Frye, 2008).

Due to the uncertainty of the effect on performance, testing should be done to evaluate how rigid and semi-rigid ankle braces can affect a volleyball athlete's skill related performance. This study included measurements of volleyball player's vertical jump, straight line sprint speed, and lateral movement speed on three separate occasions using three different bracing conditions. The athletes performed these tests wearing a rigid ankle brace, a semi-rigid ankle brace, and no brace at all. It was hypothesized that semi-rigid ankle braces would be superior to rigid ankle braces on the skill related measures amongst the NCAA Division II volleyball players.

II. Methodology

Participants

Members of a United States Division II NCAA women's volleyball team were recruited for the study during the off-season. The official roster was composed of thirteen athletes (eight outside hitters, one setter, two middle blockers, and two defensive specialists). The participants included three freshmen, 6 sophomores, and four junior level athletes (age = 20.1 ± 2.1 years, height = 179.95 ± 3.42 cm, weight = 72.26 ± 6.01 kgs). Inclusion criteria consisted of individuals who were healthy, free from lower body injury, and cleared by the training staff for full participation. Exclusion criteria included: failing to show up to one or more testing sessions or sustaining an injury during the study that would prevent full participation.

Instrumentation

Rigid Brace: T2 Active Ankle brace (Akron, OH) was used for all rigid ankle bracing conditions (see Figure 1).

Semi-rigid brace: AS1 Pro lace-up brace (Akron, OH) was used for semi-rigid bracing conditions (see **Figure 1**).

No-Brace Condition: No-brace condition was implemented by using no brace or tape on the athlete for this session.



Figure 1. The rigid (T2 Active Ankle) and semi-rigid (AS1 Pro Lace-Up) braces worn for the skill-related performance tests.

Lower Body Power

Lower body power was measured by vertical jump using the Just Jump Mat (Rhode Island, United States). The participant squatted at a 45-degree angle of knee flexion and attempted their maximum vertical jump. They were able to use their arms to aid in attaining maximal jump height. The participants completed two jumps and the higher of the two measurements was recorded in inches (Rosenbaum et al., 2005).

Straight line speed

Straight line speed was measured by the participants completing a timed 20-yard sprint. The participants started at cone 1 and sprinted as fast as they could through cone 2 which were 20 yards apart.

Lateral movement speed

Lateral movement speed was measured by the participant completing a timed four-corner agility drill (Bot, 1999). The drill consisted of four cones placed in a square formation with each cone 25 feet apart. The participant did a walkthrough of the drill before the actual test to allow for test comprehension. The participant sprinted along line 1 and rounded the cone, then shuffled along line 2, then rounded the cone and sprinted along line 3, then rounded the cone, and shuffled along line 4 (See **Figure 2**).



Figure 2. Four corner agility drill for lateral movement speed

Demographics

Participants reported class year and position (front row/back row).

Body mass and height

Height and body mass were measured using the Health-O-Meter digital scale (New Jersey, United States). Participants removed their shoes before taking the height and weight measurements.

Procedures

All participants were informed of the procedures of the study and signed an informed consent document prior to participation. Eligible participants reported to the testing gymnasium for all testing sessions. Upon arrival, participant's height and body mass were recorded. Following baseline characteristics, participants were randomly assigned to one of the three testing conditions: rigid brace (T2 Active Ankle, Akron, OH), semi-rigid lace-up brace (AS1 Pro, Akron, OH), and a no brace condition. The participants wore the same shoe model in their

appropriate size throughout the entire testing period (Rosenbaum et al., 2005). The participants were randomly assigned to a bracing condition and an order of assessment drills. Participants then performed a 5minute pre-determined warmup wearing the brace that was prescribed to them that session. The warmup consisted of a series of dynamic upper and lower body stretches led by the instructors. Lastly, the participant completed the assessment drills, which would then complete one session. This procedure was repeated on three separate occasions, for each testing condition.

Statistical Analyses

Statistical analyses were performed using the Statistical Package for Social Sciences version 24.0. A one-way analysis of variance was used to compare the values obtained while wearing either the rigid brace, semi-rigid brace, or the no brace condition. Statistical significance was established at p < .05.

III. Results

Participant Compliance and Exercise-Related Injuries

Compliance by the volleyball players for the research was 100%, with all participants completing the three required sessions. In addition, no exercise-

related injuries were reported. Descriptive statistics are reported in **Table 1**.

Skill Related Performance Measures

The analysis indicated that lower body power was not different (see **Figure 3**) between bracing conditions, F (2,38) = .858, p = .432, there was no significant difference between the lower body skill related measures when compared across bracing condition. In regards to straight line speed, there was not a significant difference based upon bracing condition, F (2,38) = 1.144, p = .330. Furthermore, there was not a significant difference in lateral movement speed, F (2,38) = .961, p = .392, across the different bracing conditions. Averages for all conditions are reported in **Table 2**.



Figure 3. Lower body performance test measurements

Variable	$M \pm SD$
Height (cm)	179.95 ± 3.42
Weight (kgs)	72.26 ± 6.01
Number of Freshmen	3
Number of Sophomores	6
Number of Juniors	4
Number of Outside Hitters	8
Number of Setters	1
Number of Middle Blocker	2
Number of Defensive Specialist	2

Table 1. Participant Characteristics

Note. Values are mean +/- standard deviations.

Condition	Vertical Jump (in)	Straight Line Speed (s)	Lateral Movement Speed (s)
Rigid	20.01 (1.67)	3.25 (.18)	11.55 (.34)
Semi-Rigid	19.15 (1.80)	3.33 (.18)	11.75 (.56)
No Brace	19.87 (1.64)	3.24 (.19)	11.49 (.42)

Table 2. Conditioned Lower Body Skill Related Tests

Note. Values are mean +/- standard deviation.

IV. Discussion

The focus of this study was to determine how various ankle bracing conditions affect lower body skill related measures in collegiate volleyball athletes. It was hypothesized that the semi-rigid bracing condition would result in optimal sports performance compared to the other conditions. Our findings indicate that the bracing conditions that were implemented had no significant impact on skill related performance.

Volleyball athletes use various ankle bracing conditions as a known preventative injury measure. Numerous clinical studies have been conducted regarding this correlation and found a reduction in ankle injuries with the use of ankle braces (Bot & Mechelen, 1999). Common ankle braces used in volleyball include varieties of both rigid and semirigid braces. The three conditions that the tests were performed under included a rigid brace, semi-rigid brace, and a no brace condition. The three performance measures that were tested were vertical jump height, straight-line speed, and lateral movement speed.

Vertical jump was measured due to the fact that it is a sport specific movement that translates into sport performance for volleyball athletes (Rosenbaum et al., 2005). The mean values for rigid, semi-rigid, and no brace vertical jump heights were respectively 20.01, 19.15, and 19.87 inches. The differences between the vertical jump heights were not significant. This supports the majority of previous research on the effects of ankle bracing on vertical jump height although previous research has been generally inconclusive. In a review article looking at 11 past studies, two showed negative effects of ankle bracing while the other nine showed no significant effect. The two studies were limited in that they only used one type of ankle brace (both semi-rigid braces), the 'Swede-O Universal' and 'Kallassy' brace (Bot & van Mechelen, 1999). While the results of this study strengthen the argument that bracing doesn't affect vertical height, this is not generalizable to all ankle braces, due to the variability in past research based on ankle brace brand.

Straight-line speed was measured by way of a 20-yard sprint under all three bracing conditions. A volleyball court measures 20 yards in length, which is why the 20-yard sprint test was implemented. This gave researchers a realistic measure of straight-line speed for volleyball athletes. The average straight-line sprint times for rigid, semi-rigid, and no brace conditions were respectively 3.25, 3.33, and 3.24 seconds. The difference between sprint times was not significant. This supports previous research, which encompasses a variety of sprint distances, on ankle stabilizers having no effects on sprints speed. Out of the same 11 studies, only one found an ankle brace (the Swede-O Universal) to have a negative effect on speed, but the article failed to disclose a detailed procedure, leaving the instruments, type of testing, and measurement accuracy unknown. Because other studies showed the same brand of brace as having no effect on sprint speed, the conclusion is still held that ankle-bracing has no significant effect on straight-line speed (Bot & van Mechelen, 1999). Ankle bracing should permit full dorsiflexion and plantar flexion, while only limiting inversion and eversion, therefore it is expected to have no effect on the body's ability to create maximum force during a sprint (Verbrugge, 1996). There was no significant difference in straight line speed during our test, supporting expectations that ankle bracing does not limit straight-line sprint speed.

Lateral movement speed was measured by a four-corner agility drill under all three conditions (See Figure 2). Volleyball athletes perform lateral movements constantly, as a part of game play for the sport. Using this test allows researchers to see a combination of different agility movements (Bot & Mechelen, 1999). Average time of completion in the lateral movement test for rigid, semi-rigid, and no brace conditions was respectively 11.55, 11.75, and 11.49 seconds. The difference between the three conditions was also not significant. Previous research found measuring agility drills under racing conditions was only inconclusive with regard to the 'Aircast Air-Stirrup' ankle brace. Other studies support that there is no significant difference in lateral movement speed as a result of ankle bracing (Bot & van Mechelen, 1999). Our research serves to support the findings of past literature with the implementation of a volleyballspecific agility test.

Limitations

This study was limited in that it included a smaller sample size and only female participants. In addition, it was unknown how much experience volleyball players had using different types of ankle braces. Volleyball players that are accommodated to using a specific type of ankle brace may be less affected compared to someone who has not played while wearing an ankle brace or that specific type of brace.

Future Research

Future research should be conducted with a wider subject base, potentially with male volleyball players. To expand knowledge about the consequences of prophylactic ankle-bracing, a longitudinal study could be implemented. A longitudinal study could also include groups with and without past experience using ankle braces to see whether accommodation to the ankle brace is necessary to avoid hindrance of performance. In addition, a longitudinal study could provide knowledge about how prophylactic use of ankle braces effects the strength of ankle muscles long-term. Ankle braces have been shown to decrease muscle activation in some functional exercises (Feger, Donovan, Hart, & Hertel, 2014). Therefore, more information is needed as to observe whether prophylactic ankle bracing would result in weakened muscles needed specifically for volleyball performance.

V. Conclusion

This research project featured NCAA Division II collegiate volleyball players using a variety of ankle braces and there were no complications that negatively affected the research process. Given the prevalence of ankle bracing being used in volleyball and other high risk sports, other research can be conducted using injury history of the individual athletes. The results from our study demonstrated that ankle braces do not impact sport related performance in volleyball players. While long-term effects of prophylactic ankle bracing are still unknown, the information provided by this study can assist coaches and trainers in their decision making. Coaches are constantly having to weigh the risks and benefits in decisions concerning their players. Having evidencebased information on both the benefits and the risks of ankle braces can help coaches have increased confidence that they are not compromising their player's immediate performance by implementing prophylactic ankle bracing. Given the availability of ankle braces that are easy to use and cost efficient, our findings support that the implementation of bracing as a preventative measure does not hinder sport performance in volleyball athletes.

VI. Acknowledgements

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Morality in an Apocalypse: A Character Analysis using Kant and Maslow

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Abstract – This article addresses how the relationship between morality and humanity evolves upon the disintegration of societal constraints due to the apocalypse in Station Eleven and The Road through the critical analysis of both novels. It examines the characters' different behaviors spanning their normal personality to their threatened survival state. These mannerisms are scrutinized in respect to Immanuel Kant's Categorical Imperative, specifically the universal and humanity formulations, as criterion to judge the characters' moral boundaries in comparison to pre-collapse values. Furthermore, Abraham Maslow's theory of self-actualization is employed as an additional means to evaluate the ethical principles of the characters under stressful circumstances. These two philosophies serve as a standard to explore the changes in the characters' interpretation of morality over time throughout various situations. This inquiry produced evidence suggesting that both authors believe some will self-enforce a moral code while others will choose to focus solely on survival. However, Mandel and McCarthy also portray the belief that the concept of morality will evolve and become more fluid in comparison to the pre-collapse society. This conclusion is a result of the conflicts between conscience and survival that force righteous individuals to overstep moral boundaries. Moreover, the investigation revealed the proposition that the environment could influence the principles of the characters through desensitization and instilling aggression.

I. Morality in an Apocalypse

A setting of inherent dystopia provides fruitful opportunities for criticism and scrutiny. Often, these commentaries materialize through the authors' specific choices in characterization. Such ideas are widely present in post-apocalyptic novels where the environment, alone, provides a substantial source of conflict between survival and conscience to advance character development. As formal societal constructs are effectively removed in the situation, the characters act independently of legality and are only liable to the constraints of their own personal set of ethics. By developing multiple characters in this manner, Emily St. John Mandel and Cormac McCarthy create a contrast between the portrayals of each character's interpretation of morality. This contrast typically manifests into a favoritism of one interpretation over another, which presents an effective medium for authors to comment upon their opinion of human psychology and moral foundation (Heller). Consequently, each author develops a unique version of the apocalypse to explore this issue of morality.

In Station Eleven, Mandel creates a hopeful apocalypse, depicting a collapse of civilization, but also showing its advancement towards its former precatastrophe progress (Maitzen). For instance, the survivors reestablish settlements, governments, schools, and other key institutions present in our own society (Mandel 114, 262-264). Furthermore, several of these individuals express a direct interest in preserving aspects of the past, including August, Clark, François, and the main protagonist, Kirsten. August primarily focuses on his own past, recovering Star Trek trinkets and old television guides (Mandel 39-40, 150-151). Clark and François focus on a broader scale, collecting obsolete artifacts for a museum of civilization and establishing a library complete with a newspaper containing interviews with survivors, respectively (Mandel 258, 263, 114). Meanwhile, Mandel crafts Kirsten as a champion of humanism and symbolic bridge between the past and present. She strives to preserve the artistic and literary components of the past society through her dramatic performances with the Traveling Symphony as well as spread a philosophy that there is more to life than simply survival (Mandel 57-58, 37-38). Moreover, Mandel adds an element of curiosity to Kirsten, who acts as an archeologist collecting news clippings and deciphering the history of a building's past inhabitants (Mandel 39, 129, 151). This reconstruction of precatastrophe society and the humanistic theme portrayed throughout her novel suggest that Mandel is optimistic for the survival of past moral principles within the survivors.

In stark contrast to Mandel's world, Cormac McCarthy's *The Road* takes a more gruesome route and suggests limited hope for humanity's redemption. He seems to believe that civilization will collapse into shambles and that the inherent concept of morals

present in our society will become obsolete when survival is the ultimate authority (McCarthy 181). The man and the boy present evidence of this belief through traveling on the road in search of a better life. Along this journey, the experienced man is forced to teach the naïve boy that some immoral actions must be committed to preserve their own well-being (McCarthy 77). However, at the same time, the man stresses to the boy that a fine line exists between this self-preservation and descending oneself to unremorsefully performing unspeakable horrors as other survivors had (McCarthy 256-260). Although plagued with dismal situations and lack of purpose, the pair strive to abide by their moral "good guy" code throughout the novel (Wielenberg 4).

Despite the distinct interpretations each author holds of the apocalypse, both of their protagonists, Kirsten and the man, attempt to adhere to an idealistic moral code in relation to their current survival situation. On the contrary, the antagonists in each fail to display the same consciousness of ethics. In Station Eleven, Kirsten's humanistic personality and remorse upon killing is primarily shown through the contrast with Tyler's regard of other characters as objects. Meanwhile, The Road presents the man's characterization through both his peaceful interactions with the boy and intense reactions to the various adversaries encountered on the road. Thus, both novels reflect on the relationship between morality and humanity when societal constraints disintegrate in apocalyptic situations.

The significance of undertaking this investigation lies in the examination of a question which cannot be easily reproduced in a controlled laboratory environment. An apocalypse in literature serves as this speculative analysis; the inquiry provides insight into the progression of morality, which cannot easily be tested through scientific means.

II. Kant and Maslow

To understand how humanity and morality are challenged during these apocalyptic scenarios, I focused on the comparative analysis of *Station Eleven* and *The Road* through the judgment of characters with respect to Immanuel Kant's Categorical Imperative and Abraham Maslow's theory of self-actualization. The former was used to establish a definition of morality while the latter was applied to further examine deviations from the definition of morality as established by Kant. Additionally, I further scrutinized the characters in accordance to the interpretation of the readers, who are constrained by contemporary social

morals. Using this method, I established a base behavior, when the characters are acting normally and unchallenged, to compare to their reactions when threatened. This assessment yielded evidence suggesting that, after an apocalypse, some individuals will retain humanistic views and refrain from immoral behavior while others will choose to disregard what is widely considered moral values the inherent worth of other humans. Furthermore, the novels also reveal that the fulfillment of survival needs will be a significant factor in the retention of ethics. While both the protagonists and antagonists were included in this review, it is important to note that, as opposed to the protagonists, the antagonists tended to be explored in much less detail by the authors and portrayed to the readers through the biased viewpoints of other characters despite the omniscient narrator.

The first manner used to evaluate the characters' perception of morality is derived from Kant's Categorical Imperative as developed in his Groundwork of the Metaphysics of Morals. He states that the Categorical Imperative is objectively necessary without reference to some end goal, meaning that the reasoning behind the action should be for the greater good or that it was the right thing to do rather than a self-serving goal (Kant 26). Although Kant specifically defines the Categorical Imperative in four formulations, the analysis of the characters was conducted using the universal and humanity formulas. The universal formulation can be defined through the statement: "act only in accordance with that maxim through which you can at the same time will that it become universal law" (Kant 31). Essentially, Kant commands all rational beings to live by a code of conduct which could be replicated universally and occur without contradiction. For example, if one were to steal from another, the universal formulation would will that everyone could steal, which would result in someone swiping the stolen item from the original thief, who would steal it back, creating an infinite loop. However, if someone were to buy it rather than take it by force, the cycle of buyers could theoretically be infinite, but the rights of an individual would not be violated in the process. In other words, Kant proposes that one should treat others how they wish to be treated. This idea suggests that rational beings are inherently important individuals and deserve to be universally respected as such. Kant's philosophy is explicitly expressed through his other formulation, the humanity formula.

The second means to gauge the characters' ethical values is through the humanity formula, which reads: "So act that you use humanity, whether in your own person or in the person of any other, always at the

same time as an end, never merely a means" (Kant 38). Through this statement, Kant is clearly differentiating between the treatment of humanity as an end, indicating its inherent worth, and as merely a means, suggesting that human life is disposable. For instance, if a person were to borrow money from someone under the pretenses of buying food for their hungry children, but instead spent it on their own entertainment, this person would be using the lender as merely a means. People should not be used merely as a means because Kant views humans as autonomous with their aspirations, values, and ability to make decisions based upon their own rational will (Kant 47). By deceiving the lender, the borrower is robbing them of their autonomous decision. However, if the borrower had told the truth and the lender agreed, the borrower would still be using the lender, but not in a manner which violates the formula of humanity as the lender is a willing participant.

Combining both formulas, Kant is suggesting that morality is largely based upon interactions between rational beings and the respect that each allots humanity. A morally wrong person's actions would contradict the significance of humanity and, therefore, could not be produced into universal law without conflict. Although Kant intended the Categorical Imperative to be unconditional law regardless of the situation, it was used in this investigation to determine the characters' overall moral boundaries and, thus, is not used in such a strict manner (Kant 30). As the characters adopt varying degrees of respect for humanity and face challenges of survival which put strain on these values, their perception of moral boundaries in comparison to those defined in a precollapse society is determined.

Furthermore, the behavior of the protagonists is also scrutinized against Maslow's theory of selfactualization. According to this theory, humans advance towards self-growth through the fulfillment of a hierarchy of needs: physiological, safety, love and a sense of belonging, self- esteem and self-respect, and fulfillment of potential (Maslow 394). When progressing up this pyramid, the satisfaction of needs is relative, meaning that a need of lower standing may not be completely fulfilled before a need of higher rank is also addressed, though to a proportionately lesser amount in comparison to the more basic need (Maslow 388-389). Conversely, if a need lower in rank arises, needs categorized above this lower ranked one will become relatively insignificant (Maslow 394-395). This directly relates to the morality of the characters of both novels as, due to the inherent emergency situations produced by the disintegration of society, previously satisfied needs will no longer be met (Maslow 374). During these threatening situations, the protagonists are motivated to respond to address, primarily, their physiological, security, and love needs, occasionally engaging in immoral acts to achieve them. However, the characters' degree of retention of their previously held values during and after the act provides an insight into the characters' preservation of morality.

By comparing the behaviors of the characters of both novels to Kant's philosophy and Maslow's theory, I established a set of criteria to evaluate the adherence to a moral code of conduct of modern standard. Specifically, Kant's imperatives are applied to determine the definition of pre-collapse moral values while Maslow's theory helps to explain a break from the characters' regular boundaries. Thus, the comparison of various instances of the characters' behavior over the course of the novel determined how the relationship between morality and humanity has evolved following the literary apocalypse.

III. Station Eleven

As Mandel introduces and develops Kirsten's character, the readers find her generally likeable despite the inherent dismal atmosphere. She is both an actress and amateur archeologist driven by passion and curiosity. Comparing her to Kant's imperatives, her base character adheres to a set of moral values within his guidelines. She is humanistic and acts without a self-serving ulterior motive. Rather, her purpose is to enlighten the lives of those she performs for and to recover anthropological clues of the past. Thus, she treats humanity as an end and her behaviors could easily be willed into universal law without conflict.

Evidence of these humanistic traits is visible through her belief in the motto "Because Survival is Insufficient," (Mandel 119). This Star-Trek inspired line represents her dedication to protecting the delicate artistic aspect of humanity, which would have otherwise been forgotten in a world primarily focused on survival. Every day, she risks her life to act upon the principle of her motto, acting out Shakespearean plays to remind other survivors of the complexity of the past society and that there is more to life than simply existing (Mandel 147). This practice exhibits her selflessness and understanding of the merit of individuals by dedicating her life to improving theirs. Replicated universally, this behavior would benefit the mending society and help spread a culture of revivalism and belief in more than simply survival. As this role is her livelihood, Mandel's depiction demonstrates that these views are a fundamental aspect of her nature.

Kirsten's interest in archeology furthers this conclusion. Throughout the novel, she made it a hobby to break into abandoned dwellings and attempt to decipher the history of those who lived within them (Mandel 39). For example, in the forgotten school, she examines the gymnasium pondering "How many people had stayed here? Who were they? Where had they gone?" (Mandel 129). A similar curiosity is expressed regarding the corpses found in the untouched uninhabited house: "Why hadn't the parents taken the boy into their bed, if they'd all been sick together? Perhaps the parents had died first" (Mandel 151). Both examples of anthropology display Kirsten's deep curiosity and value of people. As stated in Maslow's A Theory of Human Motivation, the desire for knowledge is an expression of selfactualization. Thus, the trait suggests that Kirsten has achieved a higher level of understanding and self-unity as she has relatively satisfied her more basic needs (Maslow 384). This allows her to focus on societal ideals such as morality (Maslow 393). By adding a component of interest in humanity and belief in individual worth, Mandel strengthens the credibility of her character.

Yet, at the same time, it is also important to note that Kirsten has character flaws. These are present but are merely mentioned by Mandel instead of explored as her other qualities were. Namely, she sleeps with a traveling peddler "more or less out of boredom" while in a relationship with a fellow actor, Sayid. As they perform A Midsummer Night's Dream together, Kirsten has difficulty meeting his eyes, representing the shame she feels for her actions (Mandel 45). This indicates that her perception of cheating as morally wrong, despite her motivation to overstep this boundary. While this suggests that Kirsten holds a moral code similar to the readers', yet does not always follow it, it also hints towards the notion that a character generally viewed as good, is not always perfect. The fact that Mandel decides not to dwell on the issue strengthens the idea that Kirsten perceives the action as morally wrong.

In stark contrast, Mandel sculpts Tyler into a despicable, unjust character. He is notorious for his insensitive and dehumanizing conduct towards other characters. This mode of action is specifically in conflict with Kant's humanity formulation as he simply uses others as a means to achieve his goals of power and control over an unwilling population. These also violate the universal formula as replication would inherently produce conflict. If they were, a slew of offenses robbing others of their autonomy would become law, leaving no one with the freedom. Furthermore, characters both from outside and within the cult are disgusted by his methods, indicating that while the general perception of moral values might be different from the pre-collapse society, Tyler's view is radical. Combined, these transgressions from Kant's interpretation of a moral character help establish the readers to build a negative view of him.

Much of Tyler's base personality is discovered from the accounts of Eleanor, Edward, Sayid, and the clarinetist. Mandel begins with Eleanor's description of Tyler's use of false kindness to establish his well-armed cult into power before collecting additional wives, including her twelve-year old self (Mandel 123, 125-126). From her account, Tyler is revealed to be a liar, manipulator, polygamist, and pedophile. Each accusation presents his objectification of other humans as he fails to treat them as individuals with life and meaning. He is working towards his goals mindless of the effects upon the autonomy of those he takes advantage of. Furthermore, each of these actions are done with the intention of furthering the influence of his violent cult and personal gain, not to act simply for the good of the action. Per the universal formulation, this behavior could not be willed into universal law. It would cause conflict as violence would create endless power struggles, lying and manipulation would eventually prove ineffective, and forced polygamy and pedophilia would be robbing of individual rights.

Nonetheless, Tyler's tendency to objectify others extends beyond St. Deborah by the Water to Edward's settlement. According to Edward, Tyler held his wife and son hostage to bargain for munitions (Mandel 273). When the wife refused to obey his wishes for her to become a spouse within the cult. Tyler shot her. He then abandons her, helpless, on the road to suffer (Mandel 274). From this recount, the readers see his character's total disregard for human life. Here, he objectifies both Edward's wife and son by holding them hostage as pawns. Furthermore, he exhibits spiteful behaviors by intentionally inflicting pain upon the wife, not to convince her to accompany them, but rather out of retaliation for her rejecting his advances. Both aspects display his use of others as a mere means to his goals; beyond their service to him, they are meaningless. This is a clear indication that his primary motivation is not for the perceived good of the action and would create conflict from being normalized in society due to the violation of autonomy. Again, the moral standpoint of both the readers and Kant's Categorical Imperative condemns these behaviors, furthering distaste for Tyler's character.

A final input is that of Sayid and the clarinetist, who continue to develop this negative portrayal of Tyler through recounting their kidnapping. They recall that Tyler subdued them with chloroform, which killed their mutual friend, Dieter. Unsurprisingly, Tyler seems unconcerned by the murder which suggests that, to Tyler, Dieter's death was a mere inconvenience to his plan, prompting the kidnapping of a substitute hostage, the clarinetist (Mandel 286-287, 291). This view presents Tyler as indifferent to the value of life, again providing evidence of his tendency to objectify humanity while acting to fulfil his goals. Moreover, his act of kidnapping and murder, though accidental, and following lack of humanistic philosophy could not be willed into universal law as it would promote a behavior destructive to the existence of society and humanity. Collectively, these accounts of Tyler's selfish devaluation of life concrete the readers' negative perception of him.

By establishing traits in Kirsten that contrast with those found in Tyler, Mandel creates a dynamic that effectively defines each as protagonist and antagonist respectively. A direct comparison between the two further exaggerates the rift between their beliefs and the readers' impressions of each. Furthermore, under scrutiny of the Categorical Imperative, the characters' motives, view of other humans as either ends or mere means, and the universalizability of their actions shows their inherent adherence to ethical principles or lack thereof. This assessment supplements the idea that Mandel's characterization presents Kirsten and Tyler on opposing sides of the spectrum, which allows for the evaluation of the progression of morality from both standpoints.

IV. The Road

Despite exploring a vastly more gruesome interpretation of the apocalypse, Cormac McCarthy scrutinizes his characters' normal behaviors in a similar manner. In *The Road*, he chooses to establish the initial character of the man through both the man's "good guy" code and the close relationship between the man and the boy. Together, these describe the man's character as trustworthy and morally-right in a world succumbing to animalistic dystopia (McCarthy 181).

McCarthy directly defines the man's ethical ideals through the "good guy code," rules that the man practices and teaches to the boy. Its commandments condemn stealing, lying, and killing while mandating dedication to promises, willingness to help others, and determination. Although some ambiguity exists due to their threatened survival, McCarthy unconditionally separates "good guys" from "bad guys" through the code's ultimatum denouncing cannibalism (Wielenberg 4). Despite the constant threat of starvation, the man refuses to resort to the barbaric act (McCarthy 128). On the contrary, the "bad guys" indiscriminately revert to satisfying their necessities, viewing humans as simply a means for survival (McCarthy 181). This unconditional definition exemplifies McCarthy's view of cannibalism as the absolute violation of humanity.

McCarthy uses both aspects of the "good guy code" to clearly outline the man's perception of morality. On one hand, it represents his ideals, suggested ethical boundaries that he would only cross if necessary for survival. On the other, it depicts his behavior and absolute limits in relation to violating human rights. Together, they serve to establish the unthreatened character of the man as righteous. This view of humanism as the defining factor of morality is upheld through the Categorical Principle as the "good guy" does not deviate from recognizing the rights of others (Wielenberg 4). Furthermore, if all were to follow this example universally, the world could achieve a better state as their actions would be truthful, caring, reliable, and selfless. However, when a character fails to uphold these boundaries, they become classified as "bad guys" by the man. This distinction indicates that he recognizes that these boundaries represent behavior that could not be universalized without contradiction.

Moreover, McCarthy also focuses on the trust within the close father-son relationship between the man and the boy to further establish the man's moral disposition. Throughout the beginning of the novel, their trust appears absolute. A particularly powerful indication of this bond is through the narration "Then they set out along the blacktop in the gunmetal light, shuffling through ash, each the other's world entire,' (McCarthy 6). The world around them is gray, bleak, and covered in ash; in other words, the world as the readers know it has crumbled and died, no longer full of the vivid signs of life. The declaration that each are the other's entire world furthers develops the importance of their relationship as it suggests they have nothing else to live for. This conviction is confirmed by a later exchange between the boy and the man "What would you do if I died? If you died I would want to die too. So you could be with me? Yes. So I could be with you. Okay" (McCarthy 11). Here, the man's reply to the boy asking about death indicates that his love for the boy is the only thing preventing his suicide. Conversely, the boy's ability to anticipate

and comfort in accepting his father's reply exhibits the extent of the boy's trust for the man. This culmination of evidence helps to further the man's peace-time characterization as a caring, trustworthy individual.

Unlike Mandel, McCarthy solely focuses on the man's normal behavior rather than that of his opponents. Despite not establishing a striking contrast, McCarthy still effectively crafts the man's character as morally-right by contemporary standards. He does so through defining both the ethical code and close relationship between the man and the boy, which establish a likable character in the eyes of the reader. Moreover, utilizing ideology similar to Kant's philosophy as a definition of virtue in regard to humanity furthers the positive sentiment towards the righteousness of the man. This judgement enhances the idea that McCarthy intentionally uses his character's progression throughout the novel to explore the man's varying adherence to his own moral code when conflicted.

V. A Test of Morals

After establishing the initial state of their characters, both authors test their characters' values by pitting them against one another. These conflicts lead the protagonists to face difficult decisions between survival and conscience. Meanwhile, the antagonists retain the same dehumanizing views and behavior.

Both Kirsten and Tyler exemplify these challenges in Station Eleven. Despite serving as the humanistic protagonist rooted in pre-collapse principles, the dismal setting forces Kirsten to act out of self-preservation, specifically by killing. Prior to the threat to her safety, Kirsten's behavior indicated that her basic needs were satisfied, allowing her to devote energy towards the well-being of others. However, when she was threatened, she was motivated to act in a manner which took the life, the autonomy, of another. This action is consistent with Maslow's theory of self-actualization, which describes changes in the motivations of behaviors based upon the loss of fulfillment of a need. In the novel, her reactions are specifically described as a "physiological response to danger" rather than an action of aggression (Mandel 295). Even though they are justifiable, she still exhibits remorse. Kirsten touches on the subject in Francois' interview, telling him how the world has changed in her lifetime: "I think of killing" (Mandel 265). Rather than referring to murderous urges, however, this fixation represents her guilt for killing two people in the past, each marked by a single knife tattoo (Mandel 295). Although tattoos in a postapocalyptic world carry a great risk for infection, Kirsten still chooses to become inked, permanently branding herself (Mandel 119). This choice emphasizes the fact that she exhibits genuine repentance for the action.

Later, when she comes in direct conflict with Tyler's henchmen, she is forced to slay yet another. While it is out of self-defense, it is murder, which is categorized as an immoral act per Kant's philosophy. However, considering the hostile environment to which she belongs, her remorse, despite the vindication of self-preservation, suggests that the act does not define her as a person lacking moral boundaries. She mentally advises her friend, who had never killed someone before, "it is possible to survive this, but not unaltered, and you will always carry these men with you through all of the nights of your life" (Mandel 296). This comment is further evidence that Kirsten is deeply scarred by death at her hands and has difficulty living with herself due to these actions. It is important to note that she retained her humanistic moral boundaries throughout the event. However, as her need for safety prevailed, she temporarily overstepped these boundaries. Despite the inherent understandability of her actions, she is still troubled that she violated these lines. Therefore, the readers see that she understands the gravity of her actions and feels anguish even though they were justifiable and, instead, judge her as a morally right person. Tyler, on the other hand, through his opposing perception of murder, is viewed in a differing light.

In contrast with Kirsten, Tyler is unconcerned with the manner he treats other characters in the novel. He feels no remorse when using them as he pleases, casting them aside after they have served their purpose. This attitude is demonstrated through his interaction with Edward's wife and Kirsten. In the former, Edward notes that as Tyler holds his wife captive, he stands there "all the time smiling, so peacefully, like they've done nothing wrong" (Mandel 273). As readers recall how Tyler captures, shoots, and abandons Edward's wife, they understand that his character is unrepentant of his dehumanization of others. The fact that he does not even seem to realize the significance of his actions suggests that he lives by a different moral code entirely.

This negative sentiment is strengthened further during his attempt to execute Kirsten. As he holds Kirsten hostage, there comes a point where "a look of perfect serenity had come over his face and he was looking at her, no, through her, a smile on his lips" (Mandel 302). By having Tyler look through Kirsten rather than listen to what she has to say, Mandel is showing that Tyler is focused more upon the act than the person involved in it. In other words, Kirsten is simply filling a role rather than being a direct target of his aggression. Moreover, his smile and serene appearance indicates a feeling of vindication and inherent lack of remorse for the act he is about to commit. Through his generalization of Kirsten's execution and inability to understand the consequence behind taking human life, Tyler is, again, displaying his complete disregard for boundaries as defined by the humanity formula of Categorical Imperative. His interpretation, in turn, could not be institutionalized as law without putting the value of human life in jeopardy. The result is a further degradation of his character in the eyes of the readers.

Considering both characters, Kirsten clearly attempts to follow the pre-collapse view of morality by maintaining her belief in the value of human life without intention of personal gain while Tyler, who completely objectifies other characters, does not. Their distinctly opposing views are what define them as protagonist and antagonist, illuminating the morally right and wrong. However, the question remains as to why they chose, or were forced into, the path that they took. Kirsten also ponders this topic: "[Tyler] was about her age. Whatever else [Tyler] had become, he'd once been a boy adrift on the road, and perhaps he'd had the misfortune of remembering everything" (Mandel 304). Her reasoning is that Tyler was scarred by both what happened to him as a child and by the actions he had taken. Once he became accustomed to violence and lost his faith in humanity, this pattern of behavior became routine despite now living in a gentler time (Mandel 146).

Kirsten, on the other hand, has no recollection of being on the road other than her brother telling her "The road...I hope you never remember it" (Mandel 304). This ominous remark provides a suggestion by Mandel that perhaps living amongst the chaos produced by the apocalypse would lead to a loss of faith in humanity. The clash between ethics and survival would result in favoritism of the latter, facilitating the objectification of others and selfpreservation over the greater good of society as the normal behavior. However, Mandel also considers the possibility of the existence of those characters who still believe in altruism and that there is more to life than just survival. While these characters would still be exposed to the same anarchy they would retain their foundation in ethical values, seeing that this act is what differentiates people from animals.

Similar to Mandel's presentation, McCarthy also exhibits the progression of morality through the

conflicts between his protagonists and antagonists. While the man and the boy are isolated from conflict, McCarthy presents the man as the "good guy," with only minor infractions of the code, such as sneaking the boy his portion of hot cocoa (McCarthy 34). When applied to survival situations, however, his demeanor is much different and the dynamic trust between the man and the boy is challenged.

The first time this problem arises is when the man and the boy stumble upon the truck man, who is described as rough, emaciated, and eating anything he can find, implying other people (McCarthy 64-65). As the truck man lunges, with a knife, for the boy, the man fires the gun, killing him (McCarthy 66). At face value, this act is murder, which is defined as wrong by the standards of both the "good guy" code and the readers. Consequently, the boy avoids speaking to the man as, in saving them, the man has violated their code (McCarthy 70, 77). By showing this rift between the boy and the man, McCarthy highlights that the man has committed an immoral act. However, at the same time, he suggests that even "good guys" cannot completely adhere to their code. This perception is clear as the man rationalizes his actions, telling the boy "Now you know [what bad guys look like]. It may happen again. My job is to take care of you... I will kill anyone who touches you." to which the boy replies "Are we still the good guys?" and the man answers "Yes. We're still the good guys" (McCarthy 77). In such context, his actions are justifiable as the man was acting to protect the boy, fulfilling the needs of love and security in Maslow's hierarchy (Maslow 379-381).

While it is still murder by definition and immoral by Kant's standards, the man recognizes that it is wrong and would have rather avoided the conflict (McCarthy 61, 65). This recognition shows his respect of human life, yet also that he will not hesitate to cross his moral boundaries if he determines that it is necessary for survival of himself and the boy. In turn, this idea presents the notion that McCarthy believes that the apocalypse will leave needs unmet, posing a challenge to adhere to pre-collapse moral values, which were established in a time of peace and stability. Only the "good guys" will make an effort for righteousness while the "bad guys" will succumb completely to the needs of survival.

On the other hand, both the truck man and his companions are branded "bad guys" as the readers discover that the latter had eaten their fallen comrade (McCarthy 71). According to the "good guy code", cannibalism is the ultimate violation, a boundary that the man chooses he will never cross (McCarthy 128). He decides that while survival is important, the conscientious consequence of eating another human being outweighs this end. As a violation of this value signifies the rejection of human worth in favor of strictly survival, he is constantly disgusted by those like the truck people who do not respect the worth of others, violating the humanity formula. Therefore, by holding himself and the boy to the "good guy code," they are perceived by readers as morally superior to the antagonists represented in the novel (Wielenberg 4).

McCarthy furthers this idea as the man and the boy encounter the group of cannibals. While the pair never make direct contact with the group, they find a locked room filled with bloodied amputees, the stumps of their limbs crudely cauterized. The details of the spit and iron rods outside confirm suspicions: the cannibals had premeditated how to capture and hold their prey as livestock awaiting the (McCarthy 110). However, instead of instantly killing them, the cannibals prolong their meal by only taking one limb at a time. They act with a self-serving goal in mind, treating their victims as a means for their own survival, not for the good of humanity.

Consequently, their actions are in complete opposition of Kant's Categorical Imperative. By the definition of the humanity formula, the offense resides in the lack of respect for human autonomy. Meanwhile, according to the universal formulation, the group's actions are wrong due to the inherent inability to commute cannibalism into universal law and how the limited nature of their goals would cause them, too, to fall victim to their own crime. While it could be argued that the cannibals' basic physiological needs are unmet, warranting motivation for their behavior as proposed by Maslow's hierarchy (Maslow 373), there is no hesitation or mercy exhibited by the group as meal rationing outweighs human suffering. This lack suggests that while their actions may be fulfilling their needs, there is not an underlying appreciation of human worth or remorse. As a result, it becomes clear to the readers that the cannibals do not follow a moral code as defined by the Categorical Imperative.

While cannibalism is defined as the worst offense of the "good guy code," this adaptation compounds the severity of the offense. Both the protagonists and readers are disgusted and brand the group despicable. This reaction shows how lowering oneself to animalistic behavior with human intelligence destroys everything that humanity and civilization had sought to banish. Meanwhile, the man's infraction of killing the truck man out of selfdefense pales in comparison, both in how McCarthy presents the situation and by the readers' standards. This contrast suggests two distinct directions that individuals can take after the apocalypse: to scarcely survive but adhere to morals or to live relatively comfortably without consideration of humanity.

Moreover, the interaction with the cannibals also presents another consideration of the man's character through his position on helping others. A short while after the incident, the boy rationalizes from the man's teachings that they could not have helped the other people because, if they did, they would face the same fate (McCarthy 127). Their reasoning directly relates to Maslow's hierarchy as by first addressing the more basic needs of security, the man must focus less upon his conscience and the "good guy" code (Maslow 379). This reluctance is present with other characters, including the burnt man, little boy, and Eli. In the first two cases, the man outright denies the boy helping them. However, after much pleading from the boy, the man chooses to allow a single cup of fruit to be given to Eli.

Thinking in terms of Maslow's theory, the man chooses to satisfy their immediate needs before those related to social life or those of others (Maslow 394-395). For example, with the cannibals, their safety is compromised. With the burnt man, they are on the verge of starvation, and with the little boy, they would both be closer to starvation and attract attention to themselves (McCarthy 50, 84-86). Meanwhile, the man and the boy had just been fed extremely well at the bunker and had thoroughly checked for a ruse before helping Eli (McCarthy 138, 161-163). Therefore, as their basic needs had relatively been met. the man permits the boy to offer a can of fruit. The satisfaction of needs directly relates to how the man teaches the boy ethics. In the man's mind, their safety is their priority over that of others. His reasoning depicts to the reader how the view of morality has progressed from before to after the apocalypse: for those who strive to uphold it, the basic needs of survival must first be met. Even though this interpretation is conditional, his moral boundaries continue to exist.

McCarthy continues to develop the idea of differing behaviors when threatened versus a state of stability through the thief, who steals all the supplies from the man and the boy. After tracking him down, the man forces the thief to return everything plus the clothes off his back. Later, after much chiding from the boy, the man leaves the clothes on the road (McCarthy 256- 260). This particular section presents a desire for revenge which is not visible prior as the man chooses to make the thief suffer in the same manner that he would have so easily allowed the man and the boy to endure (McCarthy 257). The thief simply swipes the items while the man and the boy are distracted. He does not threaten a violent death as the other antagonists do. Yet, uniquely, the man decides to leave him in a worse state than he was before, overlooking previous moral boundaries. His actions demonstrate how the man is not a perfect "good guy" and suggests that while actively threatened, the man only considers the physiological and security needs of Maslow's hierarchy, rather than the higher state of morals. However, as their survival returns to a stable state and the boy, who also serves as a second conscience here, reminds him of his code and the value of other humans no matter how vile they are, the man returns to his previously established humanistic principles. Perhaps McCarthy is also suggesting that as the survivors of the apocalypse are increasingly exposed to the despicable acts of other survivors, they begin to adapt and assimilate to this state. The question of humanity becomes how long the ethical reaches of the past society will continue to have an impact on the survivors. Some will yield sooner than others and, as more continue to die, the "good guys" will become fewer in number until humanity, as the readers perceive it, has devolved into chaos and can no longer be defined as civilized.

The final major adversary that the man encounters is the arrow man, who fires arrows, unprovoked, upon the man and the boy, wounding the man's leg. The man then fires the flare pistol, striking the arrow man in the chest. His fate is indeterminate; however, it is certain that the arrow man is, at least, disabled by the shot (McCarthy 263-264). In firing upon the pair unprovoked, presumably to kill them for food, the readers view his character as a "bad guy." He is shown to act without consideration of the autonomy of the man and the boy, instead viewing them as an end to his goal. This indicates a breach in the humanity formula similar to the rest of the antagonists throughout the novel and, thus, could not serve as universal law. In contrast, the man and the boy are seen by the readers as innocent victims, who act out of selfpreservation.

Per Maslow's theory, the man was motivated by a deficit in his and the boy's need for security, which rationalizes the man's action of firing upon the arrow man (Maslow 379). By having a justifiable reason behind his actions and continuing to uphold his moral principles after the act, the readers vindicate the man.

When later asked by the boy if the man had killed the arrow man, the man quickly answers no. sticking to his verdict despite pressure from the boy (McCarthy 270). As mentioned prior, the fate of the arrow man was presented with uncertainty about his survival, meaning that the man could either be truthful or lying. As a major factor in his relationship with the boy is maintaining a good moral code, there would be no reason for the man to compromise their trust by admitting that he killed the man. The fact that the man is not above stretching the truth or outright lying to the boy to protect him and their relationship furthers the plausibility of this outcome (McCarthy 34, 87). By assuming, or rather repressing the idea that the arrow man will likely not survive, the man shows that he still is vested in the ethical values of the past where he sees murder as wrong even though he is forced to kill to save himself and the boy, showing that he still believes in the importance of human worth. This understanding, again, is an indication of how morality was preserved through the man and the boy while the arrow man, not caring about humanity, is perceived as a "bad guy."

VI. Conclusion

Through displaying their originally morallyright characters in situations where they must overstep their ethical boundaries for the sake of survival, both authors are suggesting that after an apocalypse, morality tends to be more fluid. They imply that very few absolutes exist when societal laws cease to govern the people. However, they also maintain that some will choose to live by an ethical code while others will focus solely on survival. With Kirsten, she maintains a humanistic view throughout the novel, feeling genuine remorse for killing the men, even for selfprotection. Although he does not display the same remorse as Kirsten, the man also adheres to his moral code despite temptations to wrongfully overstep its boundaries. Meanwhile, both Tyler and the "bad guys" fail to exhibit any consideration of the inherent worth of human life through their actions. This distinction established while contrasting these characters fosters the analysis of the progression of morality. As a result, both authors investigate an idea unquantifiable by science, using the apocalypse as a vehicle to examine human virtue.

Both novels present the idea that some individuals will retain a relatively humanistic view while others will choose to disregard humans as means for their survival. In peaceful situations, both Mandel and McCarthy present their protagonists as morallyright, upholding this principle without reference to a specific end other than humanity itself. These actions are received in a positive manner when compared to the stipulations of Kant's Categorical Imperative as they prove a respect for human rights and inherent worth in a manner that would benefit society were it to become universal law. Meanwhile, the authors characterized their antagonists as despicable and immoral. These characters fit under the dehumanization category of Kant's philosophy for failing to acknowledge other humans as more than a tool for survival. Moreover, interpreting their actions into universal law would prove impossible as their behaviors would contradict autonomy and human rights.

Furthermore, the authors place their characters in situations where their hierarchy of needs as outlined in Maslow's theory of self-actualization are not met. This situation causes both the protagonists and antagonists react, overstepping moral boundaries in order to ensure their survival. However, Mandel and McCarthy make the distinction that their protagonists are mindful of human life and understand the difference between right and wrong. Alternatively, the antagonists maintain the same viewpoints as they do during a non-life-threatening event, immoral, selfserving, and dehumanizing. This evidence is a further indication of the stark difference between the protagonists and antagonists. The protagonists are shown approaching a state closer to self-actualization through their moral acts and ability to think beyond their needs to those of others (Maslow 382–383). Meanwhile, the antagonists act in opposition of this principle despite having their lower needs relatively met, showing a lack of moral consciousness.

Moreover, Mandel and McCarthy also seem to suggest that unsatisfied needs coupled with an immoral environment could influence virtuous characters to emulate the surrounding dystopia. This idea manifests itself as the protagonists begin to take actions similar to those of the barbaric individuals as well as potentially explaining the radical behaviors of the antagonists. Both authors present this phenomenon, Mandel through the conversion of Tyler from an originally innocent boy to a vicious cult leader and McCarthy in the man's momentary resort to revenge on the thief.

Although each novel offers a vastly different interpretation of the apocalypse, they present similar evaluations of the characters. Both authors' interpretations of the relationship between morality and humanity when humans are reliant solely on conscience for moral boundaries parallel one another. This commonality suggests that the retention of moral boundaries despite the lack of societal barriers is an internal, individual choice: the good choose to keep them, while the wicked overstep them freely.

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An Art Corrupted: Classical Music and Musicians in the Third Reich

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Abstract – This article examines the importance of classical music to the nationalism of the Third Reich, the policies and attitudes the regime adopted regarding classical music, and the subsequent effect on the lives of musicians living in the Reich. To this end, the experiences of several individual musicians are detailed, including those who were oppressed by the regime, used it to their advantage, and, in rare cases, openly opposed it. The enduring climate of anti-Semitism in both German and global society as a result of Nazi Germany's legacy is also discussed, including the unresolved issue of harassment and bigotry that musicians of Jewish heritage face in Germany's classical music scene to this day.

I. Introduction

Underneath the Austrian town of Altaussee lies an enormous salt mine, featuring a vast network of tunnels and shafts. On May 21, 1945, George Stout, an American "Monuments Man" tasked with protecting culturally significant items such as paintings and sculptures from the ravages of war, arrived at the mine to discover its miles-long tunnels crammed with hordes of priceless artwork, all of which the Nazis stole from museums, churches, and private citizens across Europe. Stout counted 6,577 paintings, 2,300 watercolors, 137 sculptures, and a massive amount of other art.¹ This was to be Adolf Hitler's art collection, intended for display at his planned Führermuseum. As one might infer, Hitler was an avid art enthusiast, and believed that German art should reflect notions of Aryan and Germanic supremacy, free of Jewish influence.² This went for all forms of art, including music, which historians tend to neglect when examining the artistic priorities of Nazi Germany. Although the Nazi's predilection for physical artwork is more obvious, music was equally important to their sense of nationalism. Indeed, in one of the Nazi's underground art stashes in Siegen, Germany, the Monuments Men discovered the manuscript to Ludwig van Beethoven's Sixth Symphony.³ Musicians were equally as susceptible to oppression for being out of lockstep with the regime as other artists were.

This article shows that the Third Reich, considering classical music to be essential to its sense of national and racial superiority, adopted attitudes and policies which profoundly affected the lives of musicians in Germany. Those effects will be demonstrated by describing the experiences of individual musicians who found themselves among either the avowed racial and political enemies of the state, or the beneficiaries of its good graces. In the wake of Nazi Germany's legacy, the issue of anti-Semitism in the German classical music scene has yet to be resolved, and warrants a deeper conversation regarding the challenges faced by musicians of Jewish heritage in Germany today.

II. Nationalism in German Music: Origins and Nazi Policies

In 1850, famed German composer Richard Wagner published an essay called *Das Judenthum in der Musik*, or *Judaism in Music*.⁴ Throughout the essay, Wagner lambasts Jewish musicians, arguing that their culture will never assimilate into German culture, and consequently, they will never learn to compose proper "German" music. Wagner singles out German Jewish composer Felix Mendelssohn in particular, claiming that, even though a gifted composer, Mendelssohn cannot divorce himself from mimicking the style of long-past German composers such as J.S. Bach, and is incapable of composing complex music such as opera. Wagner criticizes Jews in other forms of art as well. He attacks poet Heinrich

¹ Jim Morrison, "The True Story of the Monuments Men." *Smithsonian*, February 7, 2014.

https://www.smithsonianmag.com/history/true-story-monuments-men-180949569/

² "Nazi Approved Art." *University of South Florida*, last modified 2013.

https://fcit.usf.edu/holocaust/arts/ARTREICH.HTM

³ Robert M. Edsel, *The Monuments Men.* New York: Back Bay Books, 2013.

⁴ Michael Haas, *Forbidden Music: Jewish Composers Banned By the Nazis* (Yale University Press, 2013), 28-31.

Heine, describing him as "the conscience of Judaism, just as Judaism is the evil conscience of our modern Civilization."⁵ In his concluding paragraph, Wagner states that "to become Man at once with us… means firstly for the Jew as much as ceasing to be a Jew."

In Nazi Germany, Wagner was held up as a national hero. In 1933, the fiftieth anniversary of Wagner's death, an association known as the Richard Wagner Society made a public call for Germans to uphold "the national Germanic spirit of Richard Wagner," and Adolf Hitler was named the executor of Wagner's will.⁶ That same year, Wagner's opera Der Meistersinger von Nurnberg was named the official state opera of Nazi Germany by propaganda minister Joseph Goebbels, who described it as the "most German" of Wagner's operas.⁷ Adolf Hitler, for his part, had found in Wagner a prominent historical figure who completely matched both his artistic and social ideals. As a young man, Hitler's aspirations for an art career were dashed when he was repeatedly denied admission to Berlin's art academies, his skills "unsatisfactory" and his tastes too conservative. Now, after rising to power by riding the wave of resentment towards the perceived threat of the Jewish bourgeoise in interwar Berlin, Hitler was poised to mold the Third Reich in his artistic image.⁸ Richard Wagner, with his grand, epic operatic style, combined with his staunch anti-Semitist rhetoric, was irresistible to Hitler, who made Wagner the heart and soul of music in the Third Reich. This would greatly influence state attitudes and policies that suppressed the work of Jewish musicians, including those of past generations.⁹ Indeed, Felix Mendelssohn's music was banned in the Third Reich, and his statue in front of the Leipzig Conservatory was destroyed.¹⁰

Wagner's effect on Nazism was profound. The Völkischer Beobachter, the official newspaper of the Nazi Party, cited Wagner's expressed opinions on nearly every matter important to Nazi Germany, including racism towards Jews. According to David B. Dennis, throughout the newspaper's run, Richard Wagner was the subject of 243 articles, more than any other composer.¹¹ The Nazis also hailed legendary composer Wolfgang Amadeus Mozart as a German icon, but attacked Lorenzo Da Ponte, a Jewish librettist¹² who collaborated with Mozart on such famous operas as Don Giovanni and The Magic Flute. Instead of acknowledging the highly successful artistic collaboration between the two, the Völkischer claimed that Mozart managed to write his great operas in spite of Da Ponte, whom they categorized as one of the "crummy bunch of Jews who write too much." Dennis further writes that such concerns led to the founding of the office Reichsstelle für Musikbearbeitung, which was tasked with, among other things, taking "German masterworks" and replacing any text within them that was written by anyone of Jewish descent.¹³ All of this set the stage for the regime's persecution of Jews, and the oppressive environment it created for artists of any "undesirable" ethnic background.

III. Jewish Musicians in the Third Reich

The mysterious Reichstag fire of February 27, 1933, provided Hitler and the Nazis, who had only recently come to power, all the excuse they needed to establish a police state aimed at oppressing their declared political and racial enemies. While their immediate reaction was to round up political enemies such as Communists, on April 7, they passed the Civil Service Law, which targeted Jews in public employment.¹⁴ This law banned "non-Aryan" people from serving in state-sponsored positions, and its

⁵ Richard Wagner, "Judaism in Music," trans. William Ashton Ellis. University of California-Santa Cruz, accessed 21 Mar. 2018.

https://artstream.ucsc.edu/music80y/Articles/For%20 Paper%20%231/Das%20Judenthum%20in%20der%2 0Musik.pdf

⁶ Albrecht Dümling, "The Target of Racial Purity: The 'Degenerate' Art Exhibition in Düsseldorf, 1938." In *Art, Culture, and Media Under the Third Reich,* edited by Richard A. Etlin (University of Chicago Press, 2002), 48.

⁷ Thomas S. Grey, "Wagner's *Der Meistersinger von Nurnberg* as National Opera (1868-1945)." In *Music and German National Identity*, edited by Celia Applegate and Pamela Potter (Chicago: University of Chicago Press, 2002), 95.

⁸ Peter Schjeldal, "Hitler as Artist." *The New Yorker*, last modified August 19, 2002.

https://www.newyorker.com/magazine/2002/08/19/hi tler-as-artist

⁹ Haas, *Forbidden Music*, 40.

¹⁰ R. Larry Todd, "Felix Mendelssohn." *Grove Music Online*, 2001.

¹¹ David B. Dennis, "'Honor Your German Masters': The Use and Abuse of Classical Composers in Nazi Propaganda." *Journal of Political & Military Sociology* 30 no. 2 (2002), 276-277.

¹² A librettist writes the text, or *libretto*, for an opera.

¹³ Dennis, "Honor Your German Masters," 288-289.

¹⁴ "Holocaust Timeline: The Nazification of

Germany." University of South Florida, 2005. Accessed 31 March 2018.

https://fcit.usf.edu/holocaust/timeline/nazifica.htm

effects were immediately felt in Germany's musical establishments. State-run academies for art, music, and theater saw Jewish faculty members stripped of their positions, and orchestras and opera companies lost large amounts of personnel.¹⁵ One of Berlin's premiere opera companies, the Städtische Oper, was forced to fire its founding music director, Ignaz Waghalter, its principal conductor, Fritz Stiedry, assistant conductors Berthold Goldschmidt and Kurt Sanderling, and chief administrator Rudolf Bing. Where orchestras are concerned, the Berlin Philharmonic's resultant loss in manpower prompted a letter of complaint from conductor Wilhelm Fürtwangler to Propaganda Minister Joseph Goebbels which implored Goebbels to judge musicians on the quality of their art instead of their "confessional persuasions." The appeal was ultimately in vain.¹⁶

As the Nazi era went on, the oppression of Jewish musicians in Germany continued, and became an avowed goal of the state. Goebbels himself delivered a speech on May 28, 1938, entitled "Ten Principles of German Music Creativity." In this speech, Goebbels declared: "The struggle against Judaism in German music, which Richard Wagner once carried out on his own, has therefore today become the great task of our time."¹⁷ This not only confirmed the state's admiration of Richard Wagner, reflecting Hitler's own beliefs, but established Jews as an enemy to German music.

It was not only Jews, however, that the Nazis suppressed, nor solely German musicians. A list of musical works banned from performance or distribution, entitled "First List of Undesired Musical Works," appears in the April 4, 1939, edition of the *Völkischer Beobachter* newspaper.¹⁸ The list, published at the behest of the Reich Music Examination Office, included works by African-Americans. The spiritual "Swing Low, Sweet Chariot" is included, as is the jazz standard "Caravan" by Duke Ellington. Still, Jewish musicians figure prominently in the list. Notable composers with works on the list include composer/violinist Fritz Kreisler, as well as American songwriters Irving Berlin and Cole Porter, all of whom were Jewish.

To be a Jewish musician living in Germany was difficult and frightening, and many were forced to flee the country while time allowed. One of these musicians was Kurt Weill, a German Jewish composer who had, by the time of the Nazi takeover, already established himself as a leading composer of operas and musicals, most notably Die Dreigroshenoper (The Threepenny Opera), which premiered in Berlin to wide acclaim in 1928.^{19 20} But by 1932, the rising Nazi Party was already making his life difficult. That year, his opera Die Bürgshaft was premiered in Berlin by the Städtische Oper, but was berated by the Nazi press, and was only staged three more times in Berlin before being shut down. The following year, performances of his new musical Der Silbersee were disrupted by the Nazis, and it, too, was harshly attacked in the press. In March of 1933, Weill learned that he had been blacklisted for arrest by the Nazi government, which hastened his decision to leave Germany. That month, he fled to Paris, where he stayed until moving to the United States in 1935.21

Other musicians were not so lucky. Many were rounded up and forced into concentration camps, where they almost always perished. One such concentration camp, Terezin, became home to many Jewish composers, including Viktor Ullmann, Gideon Klein, and Pavel Haas. These composers wrote choral, piano, and even orchestral works while in Terezin, composed specifically for musicians imprisoned at the camp, and the instruments at their disposal. It did not last forever, however, as most of the musicians were shipped off to Auschwitz in 1944, which spelled certain doom.²²

Life could be equally dangerous if one was a political enemy of the Nazi regime. It was relatively rare to find anyone who openly opposed the Third Reich due to the obvious dangers of doing so. But after the aforementioned Reichstag Fire of 1933, anyone who held political beliefs opposed to fascism,

¹⁵ Alan E. Steinweis, *Art, Ideology, and Economics in Nazi Germany* (Chapel Hill: University of North Carolina Press, 1993), 106.

¹⁶ Haas, Forbidden Music, 222-224.

¹⁷ Dümling, 54-55.

¹⁸ "First Listing of Undesired Musical Works." *Völkischer Beobachter*, 1939. From Calvin College: German Propaganda Archive, accessed April 3, 2018. http://research.calvin.edu/german-propagandaarchive/banned.htm

¹⁹ Michael Kater, *Composers of the Nazi Era* (New York: Oxford University Press, 2000), 58.

²⁰ Although it is conventional to keep opera names in their original language, I have translated this one due to its popularity.

²¹ Kater, Composers of the Nazi Era, 59-62.

²² Jascha Nemtsov and Beate Schroder-Nauenberg, "Music in the Inferno of the Nazi Terror: Jewish Composers in the Third Reich," *Shofar: An Interdisciplinary Journal of Jewish Studies* 18 no. 4 (2000), 79-100.

especially Communists, walked a thin line while living in Germany. The Czech composer Erwin Schulhoff, for example, ran into trouble with the Nazi government by espousing Communist sentiment and applying for Soviet citizenship. He developed these views in reaction to Germany's growing intolerance for Jews and political dissidents, and even wrote music to a libretto based on Karl Marx's *Communist Manifesto* in 1932.²³ Schulhoff was accepted as a Soviet citizen in 1941, but before he could leave, Hitler launched Germany's invasion of the Soviet Union. Schulhoff was then arrested and thrown into the Wülzburg concentration camp, dying there of tuberculosis the following year.²⁴

IV. Using the Reich as Leverage

Hitler's reign was not a death sentence for everyone, however. Some musicians used the regime to their advantage. One of the most controversial musical figures of the twentieth century was Austrian conductor Herbert von Karajan, known for his long tenure as conductor of the Berlin Philharmonic Orchestra. He joined the Nazi party in 1935, and his big break came in 1938, when the Berlin State Opera was still searching for a replacement for one of its conductors, Leo Blech, who was forced to flee Germany the previous year due to his Jewish heritage.²⁵ The upstart Herbert von Karajan, only thirty years old and already gaining recognition in concerts with the Berlin Philharmonic, was afforded the opportunity to conduct Richard Wagner's opera Tristan und Isolde with the Berlin State Opera. The performance was a huge success, audience and press alike hailing von Karajan as a "prodigy." He was officially given the job as a Berlin State Opera conductor in April 1939, this being listed among the "Führer's Birthday Honors" for that year. Von Karajan's reputation rapidly spread. The Vienna Philharmonic sought him out for guest appearances, and he took on a profitable recording contract with German record company Deutsche Grammophon.²⁶

After World War II, Herbert von Karajan was forced to defend himself in front of a "de-Nazification" committee set up by the Austrian government, his right to conduct at stake.²⁷ On March 18, 1946, he delivered a deposition in front of the committee, arguing that he was not in fact in favor with the Nazi government. He pointed to an actual incident that occurred in 1939, when he conducted a poorly-received performance of the official state opera, Der Meistersinger von Nurnberg, in Hitler's presence.²⁸ In Karajan's words: "Afterwards Hitler spoke disparagingly of me and said he would never attend another performance with myself as conductor; I was not a representative 'German conductor.'" He further stated that his marriage in 1942 to his second wife, who was part Jewish, forced him to resign from the Nazi Party after he was sent before the Party Court.²⁹ Although the Austrian board ruled in his favor, von Karajan had all but admitted that he used the Nazi regime to further his career. Indeed, in 1938, his performance of Wagner, of all composers, catapulted him into the spotlight, from which his fame only increased. One of the wealthiest and most famous conductors in history, he enjoyed a long and lucrative association with the Berlin Philharmonic, remaining affiliated with the orchestra until his death in 1989.³⁰

V. Modern-Day Impact

In the modern day, Herbert von Karajan's legacy continues to spark controversy. Oliver Rathkolb of Vienna University claims to have found evidence that von Karajan was more anti-Semitic than is commonly believed; he allegedly was part of a pre-Nazi German nationalist organization in his youth.³¹ Claims such as these are merely a symptom of a greater problem facing modern-day Germany's classical music scene. Anti-Semitism did not die with Nazi Germany, and over the years, it has continued to affect the very same institutions that struggled with it during the Nazi era. In 2000, the Berlin State Opera's then-director, Daniel Barenboim, had been trying to raise support for a merger with the Deutsche Oper,

²³ "Erwin Schulhoff," Music and the Holocaust, accessed 4 April 2018.

http://holocaustmusic.ort.org/places/camps/centraleurope/wulzburg/schulhofferwin/

²⁴ Ibid.

²⁵ Richard Osborne, *Herbert von Karajan: A Life in Music* (Boston: Northeastern University Press, 2000), 110.

²⁶ Ibid., 113-120; "Herbert von Karajan," Music and the Holocaust, accessed 4 April 2018. http://holocaustmusic.ort.org/politics-andpropaganda/third-reich/karajan-herbert-von/

²⁷ Osborne, *Herbert von Karajan*, 200.

²⁸ "Herbert von Karajan," Music and the Holocaust.
²⁹ Karajan, Herbert von. "Deposition to the Austrian denazification examining board, 18 March 1946," published in Richard Osborne, "Herbert von Karajan: A Life in Music," 748-749.

³⁰ "Herbert von Karajan," Music and the Holocaust.

³¹ Rachel Hirshfeld, "Historian Probes Conductor Von Karajan's Nazi Past." *Israel National News*, last

modified December 17, 2012.

https://www.israelnationalnews.com/News/News.asp x/163206

another Berlin opera company directed by rising star Christian Thielemann.³² Klaus Landowsky, a city politician from the Christian Democrat party, controversially described the conflict as between "the young von Karajan in Thielemann" and "the Jew Barenboim."³³

More recently, controversy brewed in 2015 when the Berlin Philharmonic's newly appointed conductor, Kirill Petrenko, was met with strong anti-Semitism in the German media after earning the position over several candidates including Christian Thielemann. Northern German Radio (NDR) described Thielemann as an expert in German orchestral sound, and Petrenko as "the tiny gnome, the Jewish caricature" often found in Richard Wagner's operas.³⁴ These issues are indicative of the legacy of the Nazi era. It is time for German society to begin a more widespread conversation dedicated to solving this issue and securing for musicians the safe environment they deserve. The lack of such a conversation has compelled many German musicians, including those of non-classical genres, to start demanding one. Israeli-born rapper Ben Salomo, who grew up in Berlin, has said that he faced violence and discrimination during his childhood as a result of his Jewish heritage, and as an adult has stopped displaying any Jewish symbols in public for fear of retribution. Recently, he told German news organization Deutsche Welle that "enough is enough," and decried the unwillingness of German society to confront anti-Semitism. Russian-German pianist Igor Levit has also demanded a "difficult discussion" about the issue, criticizing German society for allowing anti-Semitism to become "consensus."³⁵

Beyond music, it is time for society as a whole to discuss the problem of anti-Semitism, which pervades Western society. The United Kingdom

reported an all-time high of 1,382 anti-Semitic incidents in 2017, including a 36% increase in violent assaults.³⁶ In the United States, the statistics are every bit as disturbing. In 2017, the Anti-Defamation League reported 1,986 incidents, a record 57% increase from the previous year.³⁷ These statistics should motivate global society to address the issue of anti-Semitism, and ensure that people of all occupations, including musicians, do not have to face bigotry. Some work is already being done in this regard. The U.S.-based Anti-Defamation League has been working since 1913 to fight anti-Semitic hate crimes throughout the world, and, since World War II, has been promoting education regarding the Holocaust.³⁸ By supporting organizations such as these, global society can make a positive difference towards ending anti-Semitism.

VI. Conclusion

The Nazis were all too eager to imitate their leader Adolf Hitler, from his affinity for the music and writings of Richard Wagner to his desire to purge Judaism from society. The musical environment this created was dangerous for the racial and political enemies of Nazi Germany, but also afforded ample opportunities for career-minded musicians such as Herbert von Karajan, who leveraged his way to success using the notoriety he earned under the regime. Unfortunately, there are lasting negative effects from this era. Jewish musicians are still subject to bigotry in Germany, and anti-Semitism runs rampant beyond Germany as well. Now, more than seven decades after the collapse of the Nazi regime, society in Germany and beyond must intensify its efforts to deal with this issue. No one should be inhibited from practicing the art of music, or any artistic endeavor, due to religious or ethnic discrimination.

³² Roger Cohen, "Berlin Operas Are Feuding, with Anti-Semitic Overtones." *New York Times,* last modified October 21, 2000.

https://www.nytimes.com/2000/10/21/arts/berlinoperas-are-feuding-with-anti-semitic-overtones.html ³³ Ibid.

³⁴ "Berlin's New Jewish Conductor Met By Anti-Semitism in German Press." *Times of Israel*, last modified June 28, 2015.

https://www.timesofisrael.com/berlins-new-jewishconductor-faces-anti-semitic-german-press/

³⁵ Katharina Abel and Philipp Jedicke, "Enough is enough! Artists on anti-Semitism in Germany." *Deutsche Welle*, last modified April 25, 2018. https://www.dw.com/en/enough-is-enough-artists-onanti-semitism-in-germany/a-43507012

³⁶ Nadia Khomami, "Antisemitic Incidents in UK at All-time High." *The Guardian*, last modified January 31, 2018.

https://www.theguardian.com/society/2018/feb/01/an tisemitic-incidents-in-uk-at-all-time-high

³⁷ Christopher Mathias, "Report: Anti-Semitic Incidents in U.S. Rose Nearly 60 Percent in 2017." *The Huffington Post*, last modified February 27, 2018. https://www.huffingtonpost.com/entry/antisemitic-incidents-united-states-

²⁰¹⁷ us 5a956390e4b0699553cc77cb

³⁸ Cynthia Golembeski, "Anti-Defamation League." *Encyclopedia Britannica*, n.d.

https://www.britannica.com/topic/Anti-Defamation-League.

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