Lab Part 2

1. Write a function to calculate included angle from two vectors
2. Identify center of mass (com) position vs. time or 2. Identify gait speed vs. time
3. Identify ankle height vs. time (R, L)
4. Identify knee angle vs. time (R, L)
5. Set up pandas dataframe with outcome variables
6. Code rows in dataframe by participant
7. Plot the data

What to turn in

1. A completed notebook with documented code
2. The aggregated csv file

OpenPose Demo

1. Submit a photo/video of yourself being keypoint detected.
2. Submit the command line call you would use to have openpose perform keypoint detection on a sample .avi file and write the .json results to a directory in of a video itself.

In [1]:
```
# imports etc.
import validators
from pathlib import Path
import urllib.request
import numpy as np
import pandas as pd
import json
import seaborn as sns
import math
import os
import glob
from scipy import ndimage
#import requests
import matplotlib.pyplot as plt
sns.set_theme()
```

In [2]:
```
# Variables Folders and path
Folders =  glob.glob("json/json/*")
files = glob.glob("json/json/*.json", recursive = True)
data={'Folder Name':[],
        'File Name':[],
        'Frame Number':[],
        'Right knee Angle':[],
        'Left knee Angle':[],
        'Right Ankle Height':[],
        'Left Ankle Height':[],
        'Center of Mass (com)-x':[],
        'Center of Mass (com)-y':[]}
```

In [3]:
```
## Base functions for interacting with .json files
#
# The following routines allow you to load and make a basic plot of a `.json`
 file from OpenPose.
def extract_kp_from_resource(f,person_id = -1):
    """
    Extract keypoints from resource (file or url) as a numpy vector
    """
    if validators.url(f):
        json_temp = json.load(urllib.request.urlopen(u))['people']
    if Path(f).exists():
        json_temp = json.load(open(f))['people']

    try:
        # extract the keypoints of the person specified by person_id; default
 is last person identified
        keypoints = np.array(extract_kp_from_json(json_temp)["pose_keypoints_2
d"][person_id]).astype('float')
    except:
        keypoints = np.empty((75,))
        keypoints[:] = np.NaN

    # set missing points (imputed as 0) to nan so that they are not plotted
    keypoints[keypoints==0] = np.nan

    return keypoints

def extract_kp_from_json(json_people):
    """
    subfunction for extract_kp_from_resource
    """
    person_id = []
    pose_keypoints_2d = []
    for i in range(0,len(json_people)):
        person_id.append(json_people[i]["person_id"])
        pose_keypoints_2d.append(json_people[i]["pose_keypoints_2d"])
    # return a dict
    return {'person_id': person_id, 'pose_keypoints_2d': pose_keypoints_2d}

def convert_kp_to_df(keypoints):
    """
    reshape keypoint vector to dataframe
    """
    # reshape to 25 X 3; the coordinates are x, y, confidence in estimate
    kin = keypoints.reshape((-1,3))

    # create a dataframe
    df = pd.DataFrame({'keypoint': ["Nose", "Neck", "RShoulder", "RElbow", "RW
rist", "LShoulder", "LElbow", "LWrist", "MidHip", "RHip", "RKnee", "RAnkle",
"LHip", "LKnee", "LAnkle", "REye", "LEye", "REar", "LEar", "LBigToe", "LSmallT
oe", "LHeel", "RBigToe", "RSmallToe", "RHeel"], 'x': kin[:,0], 'y': kin[:,1],
'confidence': kin[:,2]})

    return df.set_index('keypoint')
```

```
def plot_body25_df(df):
    """
    plot a dataframe corresponding to body25 coordinates
    """
    segments = [['Neck', 'REar', 'LEar', 'Neck'],
        ['Nose', 'REye', 'LEye', 'Nose'],
        ['RShoulder', 'Neck', 'LShoulder','RShoulder'],
        ["LShoulder", "LElbow", "LWrist"],
        ["RShoulder", "RElbow", "RWrist"],
        ['RShoulder', 'RHip', 'LHip','LShoulder','RShoulder'],
        ['LHip', 'MidHip', 'RHip'],
        ["LHip", "LKnee", "LAnkle"],
        ["RHip", "RKnee", "RAnkle"],
        ['LAnkle', 'LHeel', 'LBigToe', 'LSmallToe', 'LAnkle'],
        ['RAnkle', 'RHeel', 'RBigToe', 'RSmallToe', 'RAnkle']]

    fig, ax = plt.subplots()
    ax.set(xlim=[0, 1920], ylim=[1080, 0], xlabel='X', ylabel='Y')
    [sns.lineplot(data=df.loc[s].reset_index(), x = "x", y = "y", ax = ax) for
s in segments]
```

In [4]:
```
# function to calculate the outcomes of the dataset:
def angle_between(v1, v2):
    """
    Returns the angle in degrees between two vectors v1 and v2:
    """
    v1= np.asarray(v1)
    v2= np.asarray(v2)
    v1_u = v1 / np.linalg.norm(v1)
    v2_u = v2 / np.linalg.norm(v2)
    return math.degrees(np.arccos(np.clip(np.dot(v1_u, v2_u), -1.0, 1.0)))

def df_to_outcomes(folder, Frames, data, files):
    """
    #Return a dataframe with kinematic outcomes derived from a single body 25
 dataframe
    """
    folder = folder.replace("\\","/")

    for i in range(len(Frames)):
        #print(folder)
        #'Right Ankle Hight
        Frame = Frames[i]
        FileName =os.path.basename(Frame)
        FrameName =os.path.basename(Frame).split("_")[1]
        data['Folder Name'].append(folder)
        data['File Name'].append(FileName)
        data['Frame Number'].append(FrameName.lstrip('0'))
        #data['Frame Number'].append(FrameName.lstrip('0')+"/"+str(len(Frame
s)))
        calc_outcomes(folder, FileName)
    return data


def calc_outcomes(folder, fileName):
    """
    Calculate outcomes from a file or  other resource
    return as a dataframe in a standerd formate
    """
    dirctory = folder+"/"+fileName
    kp_u = extract_kp_from_resource(dirctory)
    #print(dirctory)
    kp_f = extract_kp_from_resource(fileName)
    df_u = convert_kp_to_df(kp_u)
    df_f = convert_kp_to_df(kp_f)
    F=df_u
# Right Knee Angle:
    RHipx=F.iloc[9]['x'] #RHip[9], RKnee[10],RAnkle[11]
    RHipy=F.iloc[9]['y']
    RKneex=F.iloc[10]['x']
    RKneey=F.iloc[10]['y']
    RAnklex=F.iloc[11]['x']
    RAnkley=F.iloc[11]['y']

    v1R = (RHipx-RKneex, RHipy -RKneey)
    v2R = (RKneex-RAnklex, RKneey-RAnkley)
```

```
    RkneeAngle=angle_between(v1R, v2R)

# Left Knee Angle:
    LHipx=F.iloc[12]['x'] #LHip[12], LKnee[13],LAnkle[14]
    LHipy=F.iloc[12]['y']
    LKneex=F.iloc[13]['x']
    LKneey=F.iloc[13]['y']
    LAnklex=F.iloc[14]['x']
    LAnkley=F.iloc[14]['y']

    v1L = (LHipx-LKneex, LHipy -LKneey)
    v2L = (LKneex-LAnklex, LKneey-LAnkley)
    LkneeAngle=angle_between(v1L, v2L)
# Calculate Ankle Hight
    RAnkleHight=RAnkley-F.min()['y']
    LAnkleHight=LAnkley-F.min()['y']

# Calculate center of mass (COM):
# Calculate center of mass (COM):
    F=F.dropna()
    xy=F[['x','y']]
    com = tuple(np.mean(xy))
    x=com[0]
    y=com[1]

    data['Right knee Angle'].append(RkneeAngle)
    data['Left knee Angle'].append(LkneeAngle)
    data['Right Ankle Height'].append(RAnkleHight)
    data['Left Ankle Height'].append(LAnkleHight)
    data['Center of Mass (com)-x'].append(x)
    data['Center of Mass (com)-y'].append(y)
```

In [5]:
```
for folder in Folders:
    Frams = glob.glob(folder+"/*.json")
    df_to_outcomes(folder, Frams,data,files)
outcomes = pd.DataFrame(data)
outcomes
```

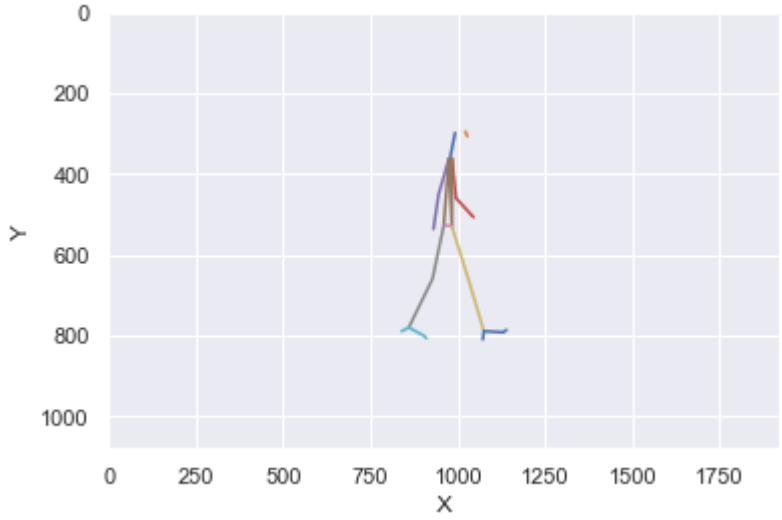
Out[5]:

	Folder Name	File Name	Frame Number	Right knee Angle	Left knee Angle	Right Ankle Height	Left Ankle Height	Cent (cc
0	json/json/1, 10-25, Normal gait, Sag, Paige	f_000000000000_keypoints.json		NaN	NaN	NaN	NaN	7.80
1	json/json/1, 10-25, Normal gait, Sag, Paige	f_000000000001_keypoints.json	1	NaN	NaN	NaN	NaN	10.55
2	json/json/1, 10-25, Normal gait, Sag, Paige	f_000000000002_keypoints.json	2	NaN	0.026289	NaN	500.247	11.18
3	json/json/1, 10-25, Normal gait, Sag, Paige	f_000000000003_keypoints.json	3	NaN	0.024306	NaN	503.207	9.58
4	json/json/1, 10-25, Normal gait, Sag, Paige	f_000000000004_keypoints.json	4	NaN	0.065731	NaN	370.929	9.47
...	...	...	...	...	...	...	...	
3370	json/json/9, 10-25 Circum hip L gait, Sag, Paige	f_000000000169_keypoints.json	169	NaN	NaN	NaN	NaN	
3371	json/json/9, 10-25 Circum hip L gait, Sag, Paige	f_000000000170_keypoints.json	170	NaN	NaN	NaN	NaN	
3372	json/json/9, 10-25 Circum hip L gait, Sag, Paige	f_000000000171_keypoints.json	171	NaN	NaN	NaN	NaN	
3373	json/json/9, 10-25 Circum hip L gait, Sag, Paige	f_000000000172_keypoints.json	172	NaN	NaN	NaN	NaN	
3374	json/json/9, 10-25 Circum hip L gait, Sag, Paige	f_000000000173_keypoints.json	173	NaN	NaN	NaN	NaN	

3375 rows × 9 columns

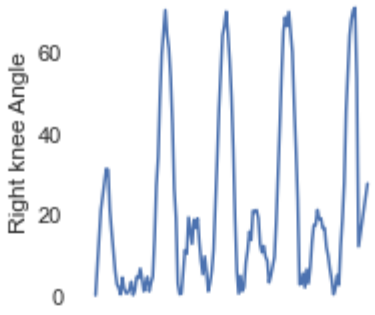
In [18]:
```
#Sample load and plot

#
u = "json/json/1, 10-25, Normal gait, Sag, Paige/f_000000000100_keypoints.jso
n"
f = 'f_000000000100_keypoints.json'

kp_u = extract_kp_from_resource(u)
kp_f = extract_kp_from_resource(f)

df_u = convert_kp_to_df(kp_u)
df_f = convert_kp_to_df(kp_f)

plot_body25_df(df_u)

#angle_between(F.loc[:,"x"].values, F.loc[:,"y"].values)
F=df_u
# Right Knee Angle:
RHipx=F.iloc[9]['x'] #RHip[9], RKnee[10],RAnkle[11]
RHipy=F.iloc[9]['y']
RKneex=F.iloc[10]['x']
RKneey=F.iloc[10]['y']
RAnklex=F.iloc[11]['x']
RAnkley=F.iloc[11]['y']

v1R = (RHipx-RKneex, RHipy -RKneey)
v2R = (RKneex-RAnklex, RKneey-RAnkley)
RkneeAngle=angle_between(v1R, v2R)

# Left Knee Angle:
LHipx=F.iloc[12]['x'] #LHip[12], LKnee[13],LAnkle[14]
LHipy=F.iloc[12]['y']
LKneex=F.iloc[13]['x']
LKneey=F.iloc[13]['y']
LAnklex=F.iloc[14]['x']
LAnkley=F.iloc[14]['y']

v1L = (LHipx-LKneex, LHipy -LKneey)
v2L = (LKneex-LAnklex, LKneey-LAnkley)
LkneeAngle=angle_between(v1L, v2L)
print("Right knee Angle:",RkneeAngle, ",Left knee Angle:",LkneeAngle)

# Ankle Hight:
RAnkleHight=RAnkley-F.min()['y']
LAnkleHight=LAnkley-F.min()['y']
print("Right Ankle Hight:",RAnkleHight, ",Left Ankle Hight:",LAnkleHight)

# Calculate center of mass (COM):
F=F.dropna()
xy=F[['x','y']]
com = tuple(np.mean(xy))
print(com[0],com[1])
```

```
Right knee Angle: 1.0192452811899542 ,Left knee Angle: 15.634537391150769
Right Ankle Hight: 494.458 ,Left Ankle Hight: 485.636
987.134695652174 574.2872608695652
```

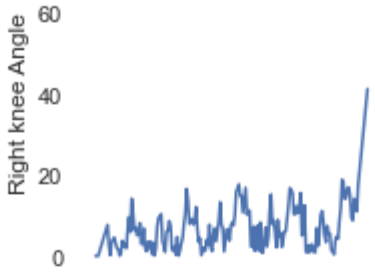


In [13]:
```
# Plot Right Knee Angle Vs. Time
g = sns.FacetGrid(outcomes, row="Folder Name",sharex=False)
g.map(sns.lineplot, "Frame Number", "Right knee Angle")
g.set(xticklabels=[])
plt.savefig('RightkneeAngle.png',dpi=300, bbox_inches='tight')
```

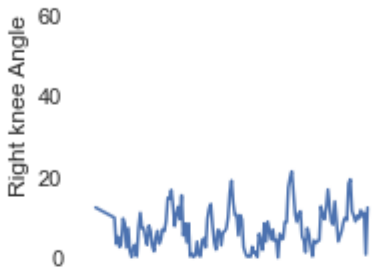
Folder Name = json/json/1, 10-25, Normal gait, Sag, Paige



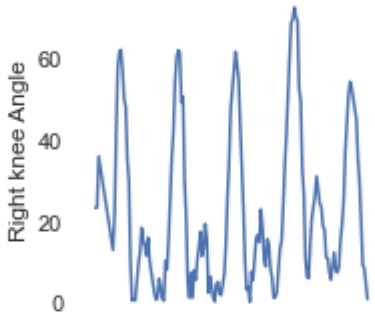
Folder Name = json/json/10, 10-25, Trendel gait, Sagittal, Paige



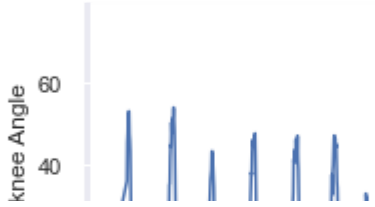
Folder Name = json/json/11, 10-25, Vaulting gait opposite side, Sag, Paige

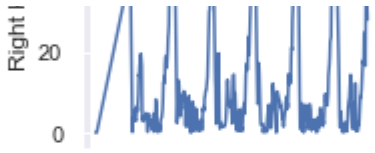


Folder Name = json/json/2, 10-25, Normal gait, Sag, Zach

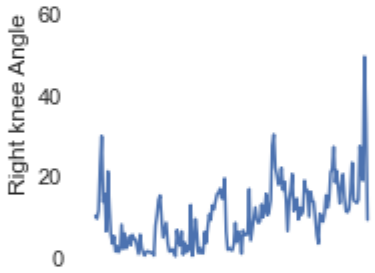


Folder Name = json/json/3, 10-25, R Hemi gait, Sag, Zach

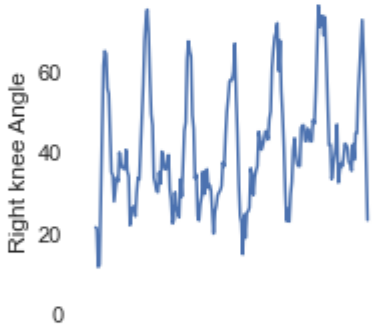




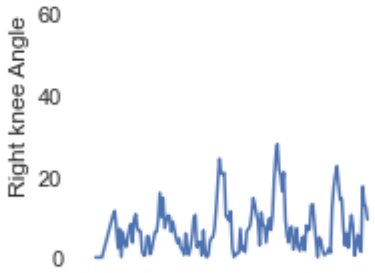
Folder Name = json/json/4, 10-25, Vaulting gait, Sag, Paige



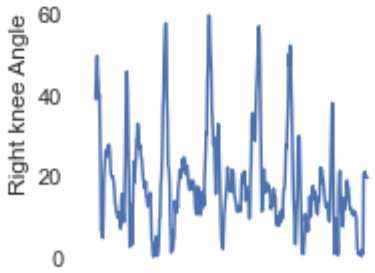
Folder Name = json/json/5, 10-25, Crouch Gait, Sag, Zach



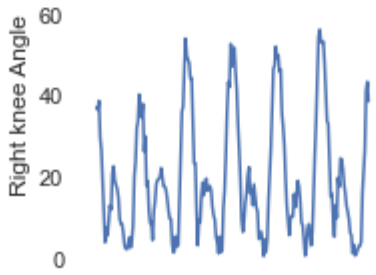
Folder Name = json/json/6, 10-25, Circum hip gait, Paige



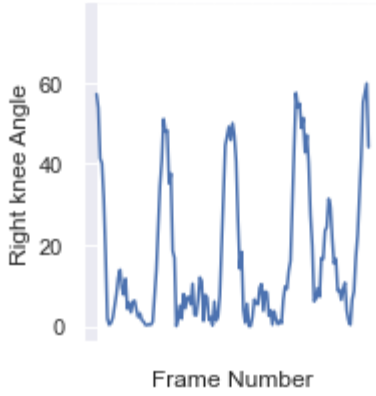
Folder Name = json/json/7, 10-25, Ataxic gait, Sag, Zach



Folder Name = json/json/8, 10-25, Limping gait, Sag, Zach

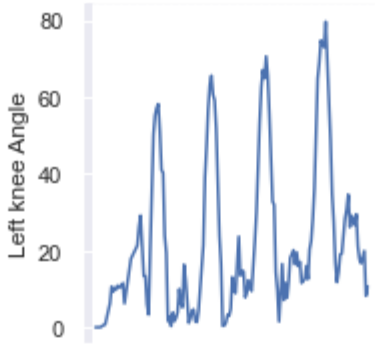


Folder Name = json/json/9, 10-25 Circum hip L gait, Sag, Paige

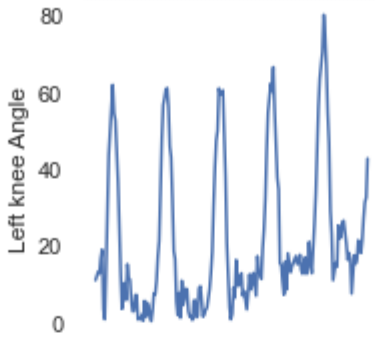


In [14]:
```
# Plot Left Knee Angle Vs. Time
g = sns.FacetGrid(outcomes, row="Folder Name",sharex=False)
g.map(sns.lineplot, "Frame Number", "Left knee Angle")
g.set(xticklabels=[])
plt.savefig('LeftkneeAngle.png',dpi=300, bbox_inches='tight')
```

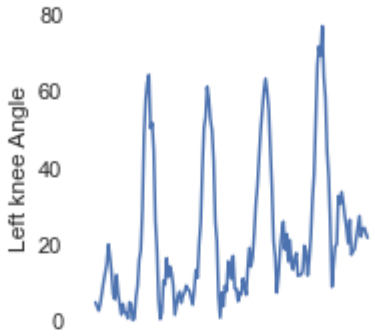
Folder Name = json/json/1, 10-25, Normal gait, Sag, Paige



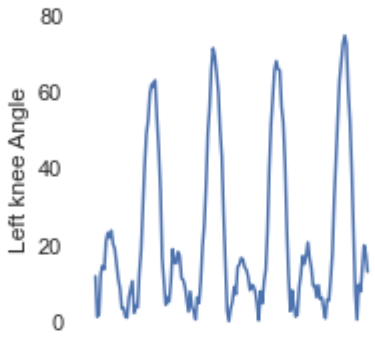
Folder Name = json/json/10, 10-25, Trendel gait, Sagittal, Paige



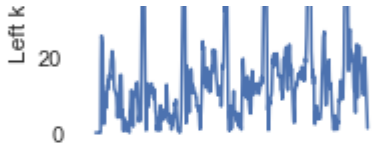
Folder Name = json/json/11, 10-25, Vaulting gait opposite side, Sag, Paige



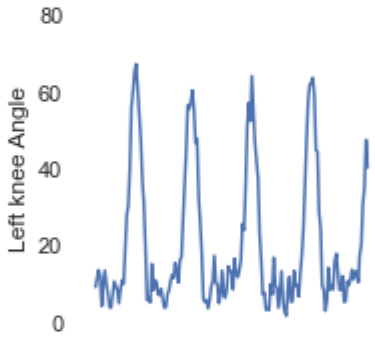
Folder Name = json/json/2, 10-25, Normal gait, Sag, Zach



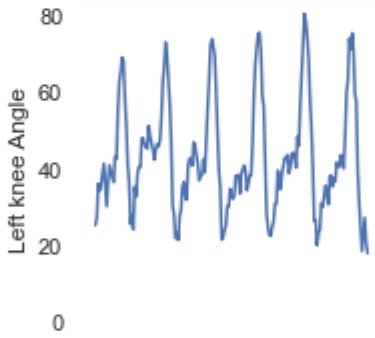
Folder Name = json/json/3, 10-25, R Hemi gait, Sag, Zach



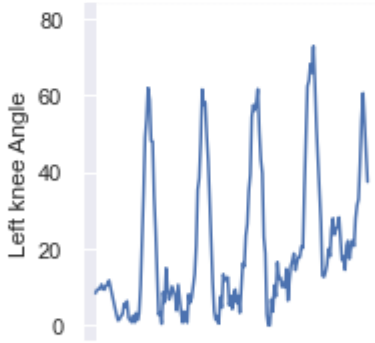
Folder Name = json/json/4, 10-25, Vaulting gait, Sag, Paige



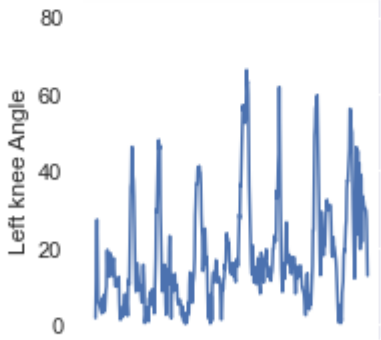
Folder Name = json/json/5, 10-25, Crouch Gait, Sag, Zach



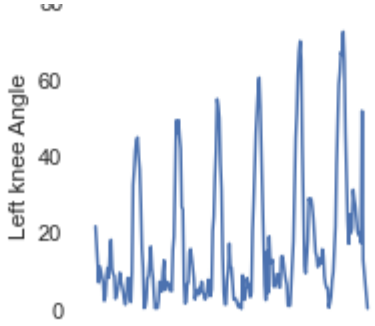
Folder Name = json/json/6, 10-25, Circum hip gait, Paige



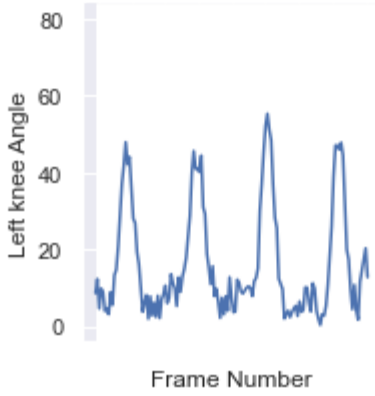
Folder Name = json/json/7, 10-25, Ataxic gait, Sag, Zach



Folder Name = json/json/8, 10-25, Limping gait, Sag, Zach

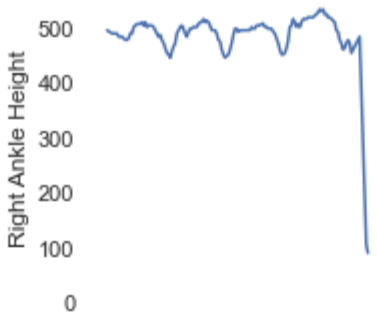


Folder Name = json/json/9, 10-25 Circum hip L gait, Sag, Paige

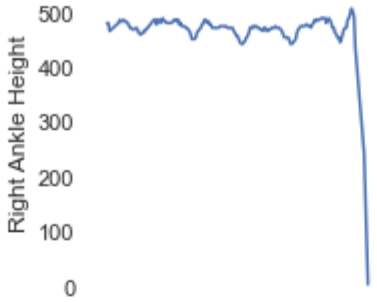


In [15]:
```
# Plot Right Ankle Hieght Vs. Time
g = sns.FacetGrid(outcomes, row="Folder Name",sharex=False)
g.map(sns.lineplot, "Frame Number", "Right Ankle Height")
g.set(xticklabels=[])
plt.savefig('RightAnkleHieght.png',dpi=300, bbox_inches='tight')
```

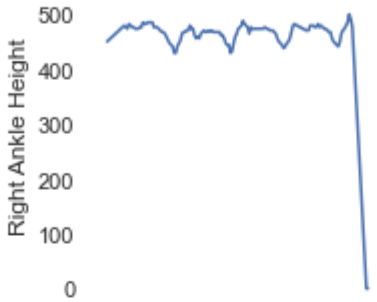
Folder Name = json/json/1, 10-25, Normal gait, Sag, Paige



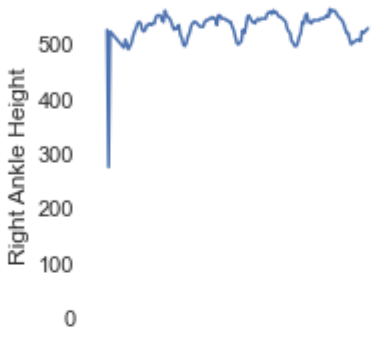
Folder Name = json/json/10, 10-25, Trendel gait, Sagittal, Paige



Folder Name = json/json/11, 10-25, Vaulting gait opposite side, Sag, Paige

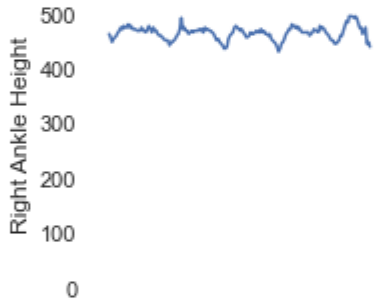


Folder Name = json/json/2, 10-25, Normal gait, Sag, Zach

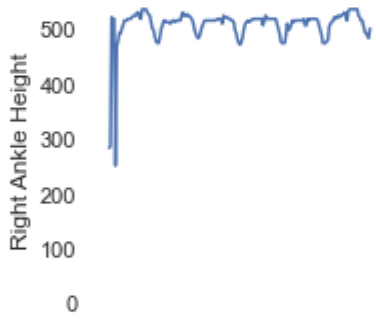


Folder Name = json/json/3, 10-25, R Hemi gait, Sag, Zach

Folder Name = json/json/4, 10-25, Vaulting gait, Sag, Paige

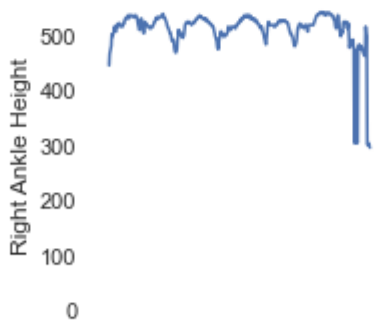


Folder Name = json/json/5, 10-25, Crouch Gait, Sag, Zach

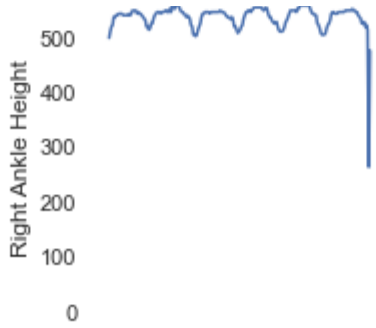


Folder Name = json/json/6, 10-25, Circum hip gait, Paige

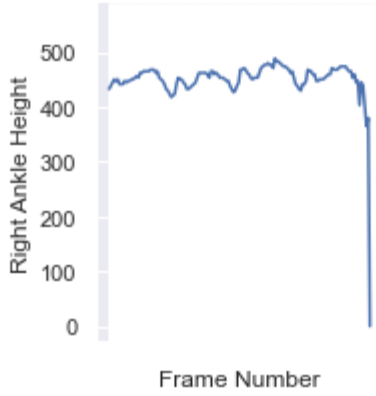
Folder Name = json/json/7, 10-25, Ataxic gait, Sag, Zach



Folder Name = json/json/8, 10-25, Limping gait, Sag, Zach

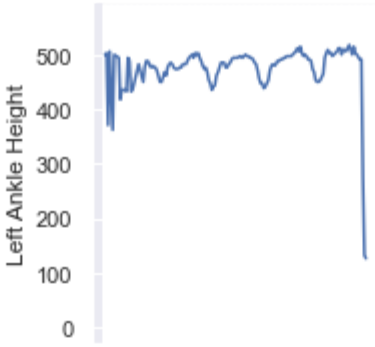


Folder Name = json/json/9, 10-25 Circum hip L gait, Sag, Paige

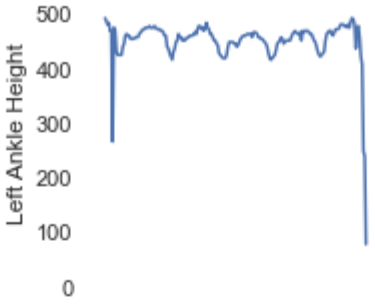


In [16]:
```
# Plot Left Ankle Hieght Vs. Time
g = sns.FacetGrid(outcomes, row="Folder Name",sharex=False)
g.map(sns.lineplot, "Frame Number", "Left Ankle Height")
g.set(xticklabels=[])
plt.savefig('LeftAnkleHieght.png',dpi=300, bbox_inches='tight')
```

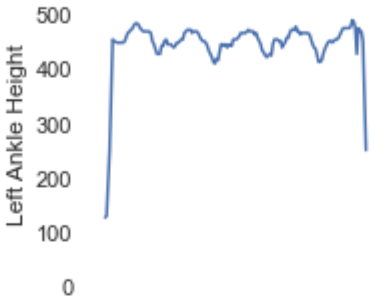
Folder Name = json/json/1, 10-25, Normal gait, Sag, Paige



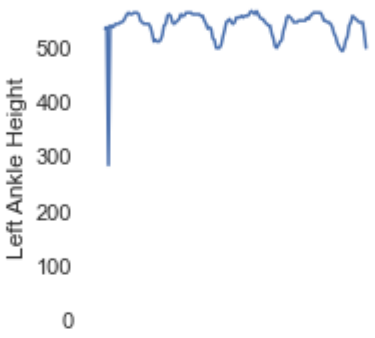
Folder Name = json/json/10, 10-25, Trendel gait, Sagittal, Paige



Folder Name = json/json/11, 10-25, Vaulting gait opposite side, Sag, Paige

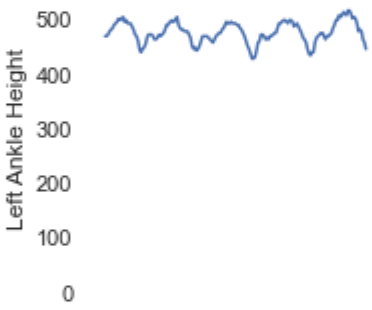


Folder Name = json/json/2, 10-25, Normal gait, Sag, Zach

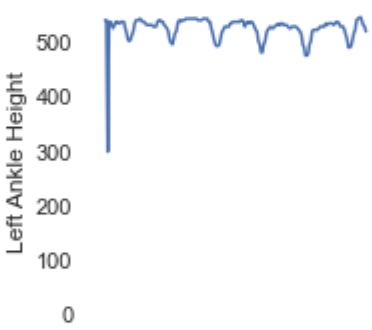


Folder Name = json/json/3, 10-25, R Hemi gait, Sag, Zach

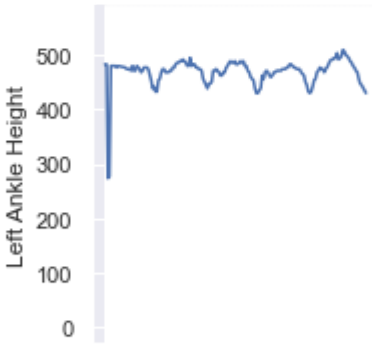
Folder Name = json/json/4, 10-25, Vaulting gait, Sag, Paige



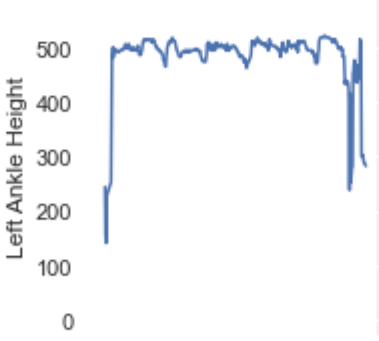
Folder Name = json/json/5, 10-25, Crouch Gait, Sag, Zach



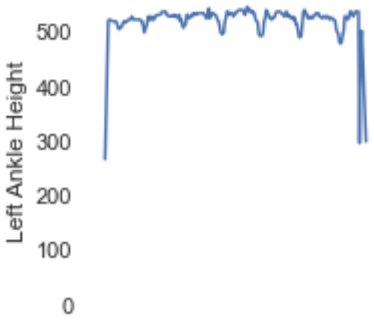
Folder Name = json/json/6, 10-25, Circum hip gait, Paige



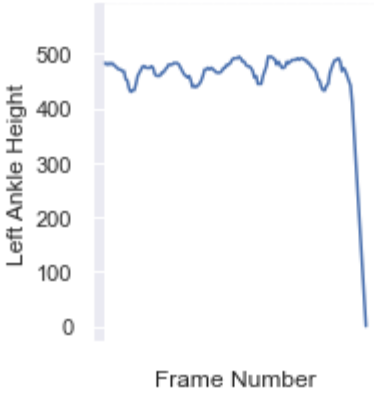
Folder Name = json/json/7, 10-25, Ataxic gait, Sag, Zach



Folder Name = json/json/8, 10-25, Limping gait, Sag, Zach

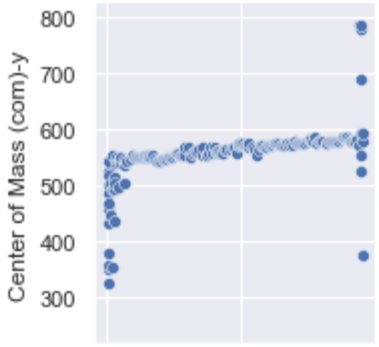


Folder Name = json/json/9, 10-25 Circum hip L gait, Sag, Paige

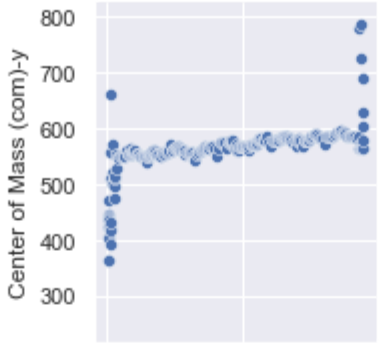


In [17]:
```
#plot The Center of Mass over time in every folder:
g = sns.FacetGrid(outcomes, row="Folder Name",sharex=False)
g.map(sns.scatterplot, "Center of Mass (com)-x", "Center of Mass (com)-y")
g.set(xticklabels=[])
plt.savefig('comvstime.png',dpi=300, bbox_inches='tight')
```

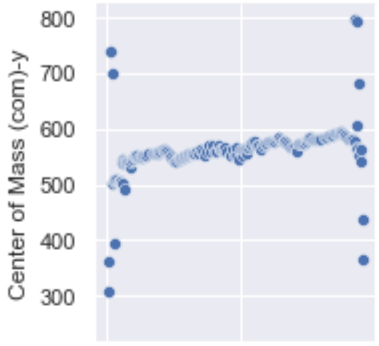
Folder Name = json/json/1, 10-25, Normal gait, Sag, Paige



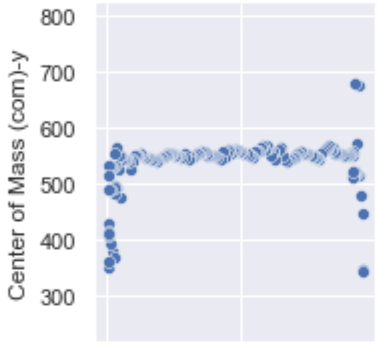
Folder Name = json/json/10, 10-25, Trendel gait, Sagittal, Paige



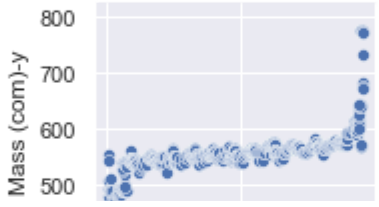
Folder Name = json/json/11, 10-25, Vaulting gait opposite side, Sag, Paige

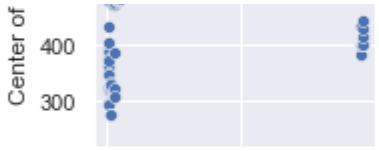


Folder Name = json/json/2, 10-25, Normal gait, Sag, Zach

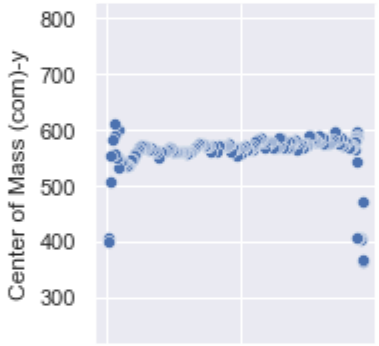


Folder Name = json/json/3, 10-25, R Hemi gait, Sag, Zach

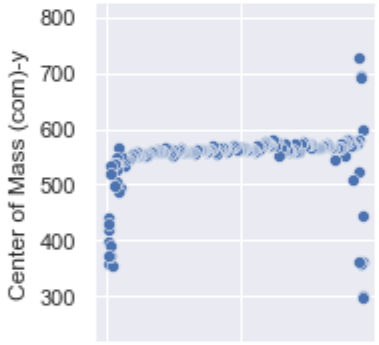




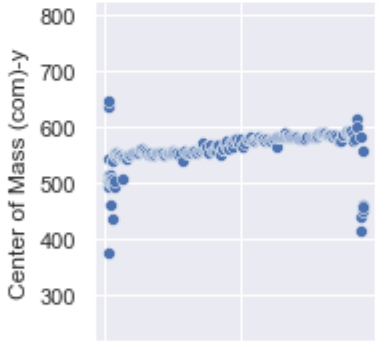
Folder Name = json/json/4, 10-25, Vaulting gait, Sag, Paige



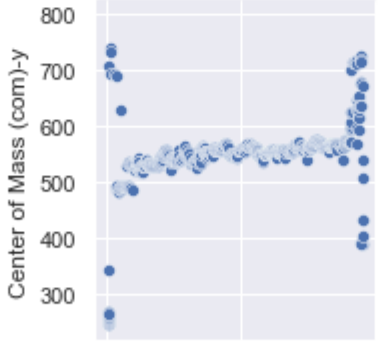
Folder Name = json/json/5, 10-25, Crouch Gait, Sag, Zach



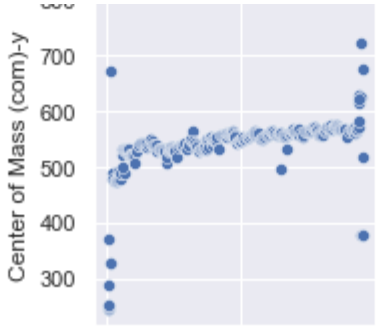
Folder Name = json/json/6, 10-25, Circum hip gait, Paige

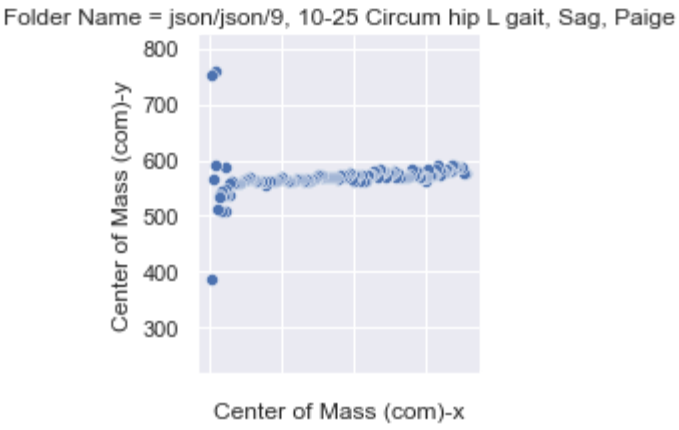


Folder Name = json/json/7, 10-25, Ataxic gait, Sag, Zach



Folder Name = json/json/8, 10-25, Limping gait, Sag, Zach





In [12]:
```
# Write the data to a `csv` file
outcomes.to_csv("outcomes.csv",index=False)
```

Running OpenPose on Windows using powershell:

A video of running the command line using the demo, a zip file for the results of a personal video (json files, video with keypoint) were submitted.

In [ ]:
```
# Command Line of openpose to preform keypoint detection on a personal video a
nd saving the video with keypoint(live iphone image)
bin\OpenPoseDemo.exe --video examples/media/InNYRita.avi --write_video NYRitew
keypoint.avi
# Command Line of openpose to save the .json files:
bin\OpenPoseDemo.exe --video examples/media/InNYRita.avi --num_gpu 0 --write_v
ideo InNYRita_output/result.avi --write_json InNYRita_output/
```